



Appendices

Designing a packaging solution for Ghanaian farmers

Master thesis by Anna Koper

Appendix 1

Interviews with professionals

1.1 Meeting Director of Holland Greentech NL

01-05-2024

Director of Holland Greentech Netherlands

Translated sections of importance from meeting dutch meeting transcript

A: My project is a bit about the combination of post harvest losses and packaging. So what I'm mainly doing now. I am a bit in research phase and I am now talking to farmers and to I have been to a market and to supermarkets and also to customers I am going to talk to. To get a good idea of how everything goes and ultimately the goal of my project is that I'm going to introduce a packaging solution somewhere and so to reduce those losses a little bit. And that can be at different levels. More like packaging for the consumer, But it can also be more about improving packaging for transport, for example, or something along those lines. The purpose of the research is to see where I'm going to put my focus for what I'm ultimately going to design.

N: Yes. And you said you? You visited farmers, too?

A: Yes, I've well, I've had a few farmers, I've, I've spoken to about 6 farmers through a farmers' meeting, But those were a bit more say local farmers who do it a bit in the somewhat old-fashioned way and then other than that I've had some calls and I've visited An organised farmer in Kumasi supplying the supermarket. Also who are also customers of yours, for example. But so I've talked to a bit of different kinds of farmers. Yeah, what I was actually mostly wondering, you guys obviously help farmers kind of get the right resources, so they can end up producing better vegetables. But of course that's mostly about producing. I was wondering if you guys also give them something about. Kind of dealing with your vegetables after harvesting or is that a bit outside your scope, so to speak.

N: That is within our scope. Only, is that something we do In collaboration with other organisations. And then there are actually two forms. I, I put it a bit immediately, also In the app to you. So what we discuss, I also said immediately In the app. So that's it yes, but we do that in collaboration with other organisations.

A: And then what exactly do you let them know, for example which crates to use or how to store.

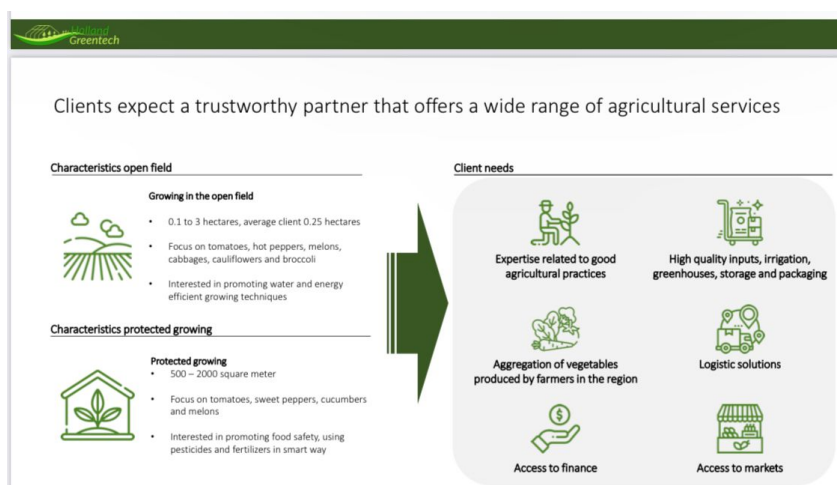
N: Yes. Begins the actually. If we want our customers to be successful, then our customers have to be able to get their produce to market well if they can't do that they will probably have to stop after that because they will become a loss-making business. We focus our immediate interest to make sure that we give good advice on how they should store and

take the produce to market after harvest. But then you actually have two forms. One form is the farmers who are just a little bit bigger. This is because you have to have enough produce what fits in a small storage there. That when the trader comes that he can fill such a truck at once. That is important because if you say but have too little produce you will never get a good price. Production has to be planned like this. If you know that on Friday that you can sell to the trader on Friday that you do have enough products. Very often you need cooperation between farmers for that. Sometimes that cooperation means that you have a bigger farmer in it who has his own storage and that the smaller farmers in the area also deliver the product to the bigger farmer. They call that a lead farmer with an outreach network. Often then is a somewhat larger company that can invest itself, for example, and thus makes private arrangements for smaller farmers in the area. A second model is if you have like smaller farmers who are in a cooperative that is going to invest in storage and for example crates. So at a cooperative that invests, for example, in huh? That's where the farmers, are the members of the cooperative. The farmers are the shareholder of the cooperative. They can, for instance, get a loan from a bank and invest in the business. Those are two different models. Yes in both those models we are trying them for example in ACHI project where you are sitting, there Delft is working with Holland Greentech and I think with 30 lead farmers. The aggregation, which is that you bring product together.

A: Yes, I had visited A farmer in Kumasi supplying the supermarket and she does it in that way that she indeed buys the vegetables over from other farmers and then packs it and delivers it to the supermarket. I have seen different things from the chain a bit, But I was also wondering, because you indeed work with different farmers as well, so some bigger and some smaller. Are those, for example, a certain type of farmers you work with?

N: I'll send you a document with where that's in okay. The type of farmers we usually work with are farmers who, for example, have an acre of land if they farm in the open field. So that's 4,000 square metres. People who have a small piece of land, but again not very small. They are people who have quite a good education. On average, they were young people. Who are also able to take part in training or learning programmes there and really seek knowledge. They are also people who can keep accounts. So really farmers who see it as a business. The reason we have these kinds of clients is that it's very difficult, because you see that for that Her in is actually not regulated at all. You actually have to do almost everything yourself. She doesn't just have to be able to remodel well. She has to completely figure out how to make sure she has enough vegetables. She has to take it to the supermarket herself, probably the supermarkets don't collect it. So basically she has to have good transport with refrigeration well, she might not have that yet, but she really should. She is already thinking about packaging herself. Probably then she also has to agree with those supermarkets well they how many vegetables they have to deliver, on which day and therefore they also have to start buying from other farmers. So you see her job has long since gone beyond just growing vegetables. She actually has to organise the whole chain. And, if you don't do that, so if you don't organise your chain and you don't manage to set up those collaborations you actually get such a low price for your vegetables that you can barely make a profit. So well, which is also true if she wants to move forward and she wants to buy some more expensive stuff, like seeds or irrigation then she has to have some money as well. And it is almost impossible to borrow money, so she has to have access to that money from her family or

maybe she has another job. People who don't have access to money, they can't take that step. Those cannot work with some more expensive inputs, so those so those so those have to deal with the difficult climate of Kumasi, for example. You then actually ask for people who can do it well and those are not the poor farmers. But suppose we would really want to work small farmers, for instance farmers with 100 m². So then we have to have 40 small farmers who have 100 m² and then you have the size of the bigger organized farmer. If those farmers organise themselves into a cooperative then we can also work with the small farmers. So it's actually either farmers like the bigger organized farmers or farmers who are organised in a cooperative. So by working with cooperatives, Holland Greentech can also work with really small farmers who have 100 m². And the reason it can do that is that the cooperative can invest in storage, but the cooperative can also borrow money and individual small farmers can't.



A: Do you happen to know who your customers usually sell to? Is that the supermarket or do farmers still often go to the local market with their produce anyway, or is it for export.

N: It is, It is almost never for export. Often they sell to a trader. A trader, so often someone is in between. It also happens that, they deliver directly. In the end, it goes to the market more often than to the supermarket. The reason it more often goes to the open to the open market. Is that supermarkets often pay late. Supermarkets in Ghana sometimes pay as late as six months to nine months. And it is sometimes even the case that they only pay for what has been sold.

A: Yes, because I had indeed heard from Susan is that she did agree on a fixed price per kilo. She just gets that throughout the year. So if a price from the farmers changes, for example, then she's out of luck. She can change that, but that was enormously difficult, she said. That is indeed because the whole organisation is very slow she said. She then basically gets paid monthly, but it is also quite often delayed. they say indeed. But she does get a kind of monthly amount for what she sells.

N: So putting product together so that you have enough product is really step one. And after that comes storage and packaging. Say you bring tomatoes to the supermarket, it's important that that tomato, that it still arrives well. A good first step is to crate it and not put

it in very big bags in which all the bottom tomatoes are finely pressed. And if you then sell it in crates, you also immediately have a standard for pricing. Small farmers are often offered a price for the harvest of an entire field. Then the trader comes along and says, "OK, this field, if we harvest that, I'll give that much for it.". That farmer has no idea whether he is making a profit or a loss with that. So if you want those farmers to go to market well, they have to have good packaging. So that packaging is also a where is one. Also ensures that a good price deal can be made.

A: I heard a lot from the smaller farmers at the farmers' meeting that usually the market women harvest themselves, but there was one farmer who said: "Yes, I get a bad price. So I did indeed find funny what you just said about that chain not really being there. So if you really want to get something out of your farm, you have to organise that yourself. There were some nice little solutions from people, though. There was a woman who was a market woman herself and there was a farmer who was a farmer himself, whose wife was a market woman, so they actually created all these shorter lines themselves to make more profit.

N: But If you go and look at packing for a moment. I think you have to pick a crop, don't you? I don't know if you've chosen a crop.

A: Not yet, But I will.

N: Yes, because You can if you are going to look at packing, then of course you can use are different types of packing. Well, you can say, that's not really packaging, but how the farmer takes it to the supermarket. Of course one of those styrofoam things with a plastic over it.

A: I went to a number of supermarkets to have a look at this, and there were a lot of plastic bags, but closed or plastic containers with foil. There was one supermarket where I had seen perforated plastic, but with, say, large holes, but you also saw that the shelves where they were placed also had much less condensation. You see that almost nowhere except at a supermarket, which suddenly had it. What I also noticed is that the packaging is mainly done because the supermarket asks for it. And ultimately because you can get more money for it, because it looks high quality or better for the consumer. But not necessarily because ultimately it can also have benefits in terms of preserving quality or keeping it good longer.

N: Suppose you grow cucumbers and you do that with a cooperative and you put a plastic band around them, then they just stay good for much longer. And that does mean that the farmer can indeed get more money for it. I can give you an, I think I have an Excel with all the different types of packaging that are available for different types of vegetables.

A: What I was also wondering. Eventually I'm going to introduce something new, probably to farmers or those cooperatives. Those have to do something new in it. Those need to start investing and putting effort into that. What is your experience of how farmers in Ghana deal with accepting and implementing new ideas. Is there some kind of a certain threshold there? Does that have to do with long or short term or investments.

N: The farmers like Susan and the young people who want to learn and who are entrepreneurial and who have good accounts who are open to it. Who really enjoy exploring with you whether there is a market opportunity somewhere and they work like an entrepreneur. And so they are curious about whether an innovation could mean more income for them. The moment you start asking small farmers who are not well organised, yes, it won't work. They don't have the organisation degree, so to speak, to be able to introduce something like this. You actually have three groups. The small farmers who are not organised. They produce mainly for their own consumption and earn a little extra by selling something. They can't invest and won't change anything.

A: No, so you think the threshold is investment or, for example, the time they would have to invest.

N: For the small farmers who are not organised, the biggest barrier is that they are not organised.

A: And for the somewhat organised farmers, say, what is important to them when they want to learn something new? That it gives profit quickly, or that they know it gives profit, or that it has to give profit within a certain period of time or if you can assure them of okay within so much time it gives profit, that they will do it?

N: Well, it depends. If you have a cooperative, it depends on what kind of one. It depends on how well organised they are and what their purpose is. Are they together to buy inputs? So if they are not cooperating for access to market then they will not be interested. If they also do marketing and sales together they will. But it won't be easy to find that. So something like what you are doing most likely works farmers like Susan, so those are those commercial smallholder farmers. What we were just talking about with a bit of money and well educated. And In the future, it should be so that it should also work for small farmers who are organised in that cooperative that also does marketing and sales. If you target it to that group, you actually target Holland Greentech's customers. I have another meeting in a moment so I'll have to get through this in a moment.

A: Totally okay. Thank you very much for all the information and have a very nice day.

N: Yes good luck, regards.

Conclusion meeting

- In collaboration with other companies HGT gives advice on how to store products and access the market to make sure customers can keep making profit to invest.
- A lot of customers from Holland Greentech sell to traders. These traders buy their produce and sell it to other people like market women. It is important that when a trader comes to buy the produce it is enough to fill a truck in order to get a good price. You often need cooperation between farmers for this and there are two main ways this is done. One is a lead farmer with storage where farmers from his or her

outreach network also deliver their vegetables. The lead farmer is usually a somewhat larger farmer that can invest in itself. Another option to supply enough vegetables is a cooperation between several small farmers. The small farmers are members/shareholders of a cooperative that can get a loan from the bank to invest.

- The type of farmers HGT works with are young, well-motivated farmers with a good education in order for them to be able to follow trainings. These are the people that really seek knowledge and see their farm as a business to invest in order to run a profit making business. They are also people who can do bookkeeping. On average they have about 1 acre of land which is 4000 m².
- It is hard for farmers in the horticulture market in Ghana since there is little to no overall regulation or organization. In order to make good profit farmers need to set up their own connections and organize their own chain, otherwise you usually get a low price for your vegetables. For example Susan. Her original business was farming, but now it is also transport from vegetables to her farm, cleaning and sorting, packaging and transporting to the supermarket. People who don't have money cannot invest and take this step of organization.
- Overall most vegetables get sold at the market. A reason for this is that supermarkets usually pay late and sometimes only for what is sold.
- Packaging can also be a way to ensure a good price per amount can be established. As opposed to buying a whole field, the price per unit can be set.
- Adoption of new things depends on the farmer. Young entrepreneurial people who have some ability to invest enjoy exploring new things to see whether an innovation can mean more profit for them. The small non-organized farmers will likely not change anything since they don't have the capacity for it.

1.2 Meeting Holland Greentech Ghana manager

12-04-2024

Holland Greentech Ghana manager

Meeting transcript

A: My name is Anna and I'm doing industrial design engineering as a study. I will be here to look at the post-harvest losses and see if I can find a packaging solution for the vegetables that will keep the vegetables fresh longer so there's less post-harvest loss. I talked about it with Lindsey and Esther and looking at a target group of the people who are willing to invest in such options. So they said that would be the lead farmers also that you are connected to and maybe other farmers but it would be for me mainly really nice to speak to some lead farmers. I heard you also have the, I don't know exactly what they are but the farm days, maybe it's also fun to visit one of those if one is there soon and then I mainly want to speak to the farmers and then to some supermarkets and market people but I think maybe The ACHI manager Ghana can also help me with that in commerce a bit.

C: I wish you were here earlier because this week we received, I have Rijkzwaan in the country now and it's the supply chain unit of Rijkzwaan trying to develop the market for us so they've been visiting the market, the supermarkets trying to get to understand the market and it's been the whole week like my other colleagues even right now today they went to the commercial farms especially for those who can pay for some of these things and supply but anyway it's fun and we can do it. But I think it would be good maybe to get their reports, I will see if we can do them and maybe you can write a little bit on their reports or something for the week because Rijkzwaan supply chain units it's also looking at that, looking at the various sample service that's for other varieties compared to ours and which ones they can bring into the markets and all those things. So I think it's a good project, more like building on what Charlotte did.

A: Yes me too, she did a very nice job of visualizing the road to market and she had some ideas for that so I can take that and see if there's a possibility to package the vegetables or where it's the best to implement that and then to see what packaging would be good or not. So the goal in the end is to see if there's some sort of packaging solution but then it is to reduce the post-service loss.

C: Let's see. We are all looking for solutions. That's how the whole system, the whole horticulture system and so it's good that we are able to come up with some of these things. We also try as much as possible to follow up to the implementation. So you are welcome to come.

A: Yeah, thank you.

C: We love you so much. And I hope that you enjoy your stay very well.

A: I think I will. Thank you so much.

C: I'm the country director for Holland Greentech. I started as the business development manager through the YEP program in Holland. So I was part of the YEP program. And Charlotte is going to be part very soon. Do you know about the YEP program?

A: Yeah, I don't know it in detail, but I heard it a little bit from her.

C: So I was part of it. When you join, it just initiates you into new countries to start developing business or projects or all those things. So I was part of it in 2019 and then I was attached to Holland Greentech to be the looker and start developing the business for how long you will take it down. So we started living through tough times and all those things a little bit, but it has been also a learning curve for us, especially if you are not a business manager or something, but if you are transitioning from a different sector to a new area. Yeah, especially, but it has been a nice time, especially with different projects coming in, with different people learning from Lindsey, learning from all the people around and all those things that made us a little bit better in terms of our management. And we do mostly Dutch products, the sales of Dutch inputs. So we have almost all the Dutch companies and lines selling their seeds and irrigation. So we don't just sell the inputs, we want to build a business for the families, so we go to the stand of admin services. So if you get input from here, we just have to move to your farm to ensure that whatever you are putting on ground is working for you and also building a very good business unit with you in terms of our culture sector, because most of the people don't value agriculture as a business. They think it's just a way of life.

A: So you want to move it a bit more to the business side?

C: Yes. They normally have the smaller farmers mostly farming in the subsistence way, providing for the family and the surplus is being sold to the market. But now we just want to let people know that agriculture is a business and we have to see it as such in that way. Because you get money or you get revenue, good revenue from agriculture and if you see other countries that have good GDP and all those things, you look back and see that it's that agriculture sector that is striving. We look at Israel, we look at Holland, so we are trying to see if we can also contribute to that culture, because we are going to do everything, so that's what we can do. In our small way, we just have to do it. We also have some projects that we are on. So we have the project, we are also being led by Deborah. Deborah is on a maternity leave now. I have to fit in a little bit for her. She will be coming back in June. So we have the ACHI which you are on now. We are about to start now preparing the implementation plan and trying to get the people that will work on the project, the recruitment of the people. The teaching of the students. We are trying to recruit them for Holland Greentech. We are also trying to provide training for all of them. We are always on the face of preparations and planning and all those things for the ACHI project. I think KAC has already started a fair amount of students. We also have the collaboration with a partnership with Alviterra, a cooperative kind of company. We are not just in Ghana, we are almost in 12 countries, African countries. For West Africa it's just few, but most of them are in East Africa.

A: Do you work with them as well?

C: Yes, we have a lot of meetings. We talk a lot of times. The countries are not the same, but sometimes we can apply certain things. We learn from each other. So in terms of the lead farmers, it's good. You know, post-harvest doesn't really start from after harvest. It starts when we start production. We are also looking into our protocols to see and make sure that farmers are getting the quality that people want. Because even during the production, if you don't do the right fertilization and correct handling of produce, you are going to have problems with the produce at the end of the day. So I think it's a hand-in-hand thing that we can all do together. In production and after production, that is when the whole process is in the mix. If you do a correct watering schedule, if you do a correct fertilization and fertilization schedule, if your protocols are intact. A protocol that you are going to get very hardy, I mean, quality fruits and nice ones also. So I think we have to look at it hand-in-hand that you can even go to the stand of getting protocols of what people want because some of the farmers are not applying the right quantities of fertilizers. They are not applying the right quantities of water. And that affects the shelf life as well of the product. But what I've realized is that most of the people that do a good job and have quality fruits, they don't have problems selling.

A: So I heard most people sell to the markets and to the supermarkets, right? And maybe to hotels or restaurants.

C: Exactly.

A: And is it also that if they have better quality fruits, they can sell it more easily, for example, to the supermarkets?

C: Yes.

A: And then they get a higher price than at the markets.

C: So when you have that quality fruits, it's also the quality fruits stay on shelf for long. So if you have quality fruits, it means that your shelf life duration is going to last quite long compared to those who don't have that quality fruits. So you have that hard skin, because you are giving it a lot of calcium, potassium. So if there's a relation, you don't give much and you are giving more nitrogen, it means that after a day or two of harvest, it's gone. So you can be able to package your stuff very well, but at the end of the day, you still have problems with your shelf life. And it's like the packaging can also help with shelf life. But then you need the good quality fruits. And then if you package them, they can have an even longer shelf life.

A: I heard there's not a lot of fresh fruits and vegetables being packaged. Like most go to the markets. But if they are being packaged, they're probably sold. Where are they sold?

C: So we have different selling points. The local markets. I'm sure you saw some of the markets in Charlottes report. So we have the local markets.

A: Is it in packaging or not? If it's sold at the markets.

C: Yeah, so when it's sold at the markets, it's mostly just that it just lies on the table without any package or something like that. There's no storage condition or something. Even put it in the sun. And then it's only at the supermarket that it's being packaged and also being kept in a very cold storage conditions.

A: And do you know if any of the lead farmers, if they are already packaging, because I heard there was someone, I don't know, I don't remember her name, but that she was already doing some packaging, like packaging or produce in a plastic bag or something.

C: Yeah, some of them do. But it all depends on where they are selling. Some of them know the malls would prefer you package it and you bring it to their shop. So it depends on where you are. So it depends on the, depends on who they sell to if they ask for packaging as well. So it's more the people who are packaging do it more because their supplier kind of, they want it. And maybe not because it will keep the vegetables more fresh.

A: Do you think people, there's a lot of people that know about that you can keep the vegetables more fresh if you package them or what kind of other benefits it could have than just that the supplier want it?

C: I think that's what I'm also saying is the chain is not subdivided because it's the farmer just know about production. Like he's an agronomist. And most of them don't have knowledge on this packaging and all those things so they sell just like that because they are done harvesting and they don't have anything to do with packaging and storage and all those things. So they just have to sell it to that to a middleman who will sell to the others. Or secondly, I think that most of them don't want the hassle of going through all these things and then at the end of the day still get the same. But also, the moment it happens like that, the families don't get a price they deserve.

A: Yeah, so if they just give the vegetables like that, or they package it they get the same price or?

C: They don't. Even with the packages, they still don't get the price. So let me assume that okay, an example is this is fresh vegetables. The packaging company packages it like this and put it on the shelf. So maybe I sell this for let's say one cent. But when the company packages and we are ready to sell for four euros. So the company can also do the whole packaging, but at the end of the day maybe you can sell for two euros. And the company will have to sell for four euros.

A: Yeah, okay, I understand. I'm going to look more at the stuff after harvesting. So do you have any idea on where there is loss the most? So for example, if they store it on the farm

or if it's during transport or maybe during the handling on the market or like the handling between transport and selling?

C: Yeah, it's all happens at that point, but I think it depends on the situation. Some of the farms are very far. So for them to get a car to transport the goods, it takes them some time. So the products are getting lost at the farm and even on the transports. The moment the truck bumps, the inside gets in. They're getting damaged. And also, it's in the sun, they transport it through a normal truck. So that's another thing that's...so it depends on the area. What goods are lost, where it happens. So it's not a general...

A: No, okay. And do you know, because there's some people packaging themselves, do you know if there's any farms that kind of do a bit like a marketing thing so that they, I don't know, have a sticker or packaging with information about it that it's...because you're trying to do things organic as well, right?

C: Like in terms of packaging?

A: Like if, yeah, if, well, if, for example, because the lead farmers and everybody connected To Holland Greentech, they kind of get the good farm practices, so maybe also less pesticides or stuff like that, so that the produce is maybe healthier. Do they also sometimes use that as a...like as marketing that they can say like, oh, this produce is more healthy than other or...

C: Yeah, some people try to, but mostly you don't see the difference. Yeah, you don't see it on the outside, no. And as much as I'm telling you that I'm having pesticide-free and all those things, I mean, other people also bring their produce in the shop. So you cannot see the difference between Holland Greentech lead farmers produce and the other produce. The other thing that really differentiates some produce when they have the green label certification.

A: And that is...what does that mean?

C: It's something like that, where we look up certification value. And that's...I'm sure that they meet the quality compliance standardization requirements.

A: And if you put that or if you say to customers that you have that, then they will pay more or there's more people that want it or...

C: That is how it's supposed to be, but there's still a little bit of...not much awareness on the healthiness of vegetables and why people should choose quality vegetables rather than the others. First of all, a lot of people are not even eating vegetables in their homes. About 80% of their meals don't add vegetables to their meal.

A: They don't at all.

C: Not at all. So when you look at that, first of all, I think this certification value, it's good, but it will take some time to get around. So it's not that they are trying their best to ensure that they give it.

So there's a sticker they put on, which you can use to identify that this farm has gone through the quality compliance and the requirements to produce a healthy vegetable for you to eat. So there's a sticker that they put on to show there's a green, satisfied produce. I think more awareness has to be made on the nutritional benefits of taking your vegetables. But it's very important even before we come to the markets and the fit and everything.

A: I think that's quite some good information. And do you, because I'm hoping to speak some of the lead farmers, if I want to contact them, do I have to do that through you or maybe through The ACHI manager Ghana if they're, because I'm going to be around Kumasi.

C: It's supposed to be Deborah, but I was not the one on the project. But Deborah is on leave, so I think maybe for now we can rely on The ACHI manager Ghana. But he also has the contact of other lead farmers in the area there.

Conclusions

- HGT supports farmers that see farming as a business and are willing to invest in their business to get more revenue. They help them with resources, services and training.
- HGT also collaborates with divisions in other African countries to learn from each other.
- The farmers connected to HGT usually sell higher quality products that have a longer shelf life than regular farmers produce and can sell their produce for more money. Packaging could help extend the shelf life more, but only if the pre-harvest and post-harvest handling goes well to produce good quality produce. Otherwise packaging also doesn't do that much good.
- Usually packaged goods are sold at the supermarket or to hotels and restaurants.
- There are many reasons for post-harvest losses and it depends on the situation where it occurs the most. Sometimes it is transport, long transport, rough roads, sun exposure, damaged goods. On the market there is usually also no shade.
- Some farmers do package their produce but it is usually because the supplier asks that from them rather than that they see the benefits for shelf life.
- The reason that people do not package is most likely because they don't know the benefits and it therefore seems like it only costs more time and money. Also sometimes the supermarket packages the products themselves with the logo of the supermarket.
- Not a lot of people do marketing of their produce. Customers don't pay that much attention to claims such as less pesticides or other things because you can't see it on the outside compared to other vegetables that do make use of pesticides.
- There are some certifications like the green label certification that ensures quality compliance, but there is not much awareness on this from the customer side.

- A lot of people in Ghana do not eat many vegetables or know that vegetables have high nutritional value.

1.3 Meeting ACHI project NL

04-04-2024

Project Manager of the ACHI project

Education & Entrepreneurship at the ACHI project

Meeting summary

The target group of the project is the commercial farmers that are connected to HGT. These are the farmers that are open to adopting new things that will help them increase the value of their harvest. Next to being willing to adopt new things they also have the money to try new things. They work on a slightly bigger scale than the 'regular' smallholder farmers. Most of these people also function as lead-farmers for Kwadaso Agricultural College. This again means that if these farmers adopt new practices they will serve as an example for new KAC students. It is important to really work with this group when researching the problem since they usually have a different approach to farming than the general smallholder farmer. An example is that some of these farmers drive their produce to the market themselves to save costs and increase the value of harvest. These are also the people that sell to supermarkets more often.

The inflow of students at KAC consists of a wide variety of people. Most of the people are between 30 to 40 years old, but also younger and older people follow the program. Some of them already have work experience and some don't. Some are farmers already while some have never done it before and some are even doing the programme next to their job.

The ideal outcome of the project for Lindsey and Esther would be a solution that actually helps and actually will be adopted in the local context. This means that it should be interesting cost-wise for the farmers. It is also crucial that the solution is reproduceable for others, so there needs to be a guide in some form to replicate the solution for others.

Conclusions

- The target group are commercial farmers and lead farmers connected to HGT. These are the farmers that are willing and able to invest and are open to adopt new things. These are also the farmers that function as an example to KAC students.
- Research in the actual context will be crucial to ensure a fitting solution that can actually be adopted. Attention needs to be paid to costs, reproducibility and a guide or instructions.

1.4 Meetings Project manager ACHI Ghana

15-04-2024

Project Manager for ACHI in Ghana at KAC & lecturer at KAC

Meeting transcript

S: So have you planned something already? Every week what you are supposed to do?

A: Yes, I wanted to speak to a lot of farmers, maybe in the first two weeks. So visit some farms so that I can ask them everything about where the post-harvest losses happen and why they are not packaging. So I can kind of find out, for example, if there is one vegetable or which part of the process it is good to maybe focus on. And then in week three also take a bit of the market with it. I can also ask it for the farmers, but I also really in the end need to know if I am going to introduce some packaging somewhere, if it is financially okay for the farmers. So I want to know also, for example, if you sell a vegetable at the market, how much can you get for it? Or if you sell it packaged in the supermarket, how much can you get for it? To see what you can invest in packaging. And then in the last part, I think that is maybe nice to do with some staff here, but I want to do a session with some people together to kind of see if we can come to a set of criteria that we need. So then I kind of, for the past weeks, I found a bit more of a focus for my project that I really want to focus on and design for. And then together we can look at some possible solutions or some criteria that are really necessary. And then if I have all that information, then I can, if I am then back in the Netherlands, I can, like I have all the information I need to start designing something.

S: So for the first two weeks, you interview the farmers and then also visit the market. I think you have to visit the market. So I need to assign you to some people to take you around.

A: Yes, that would be really nice.

S: I expect all other farmers around, maybe I would like to contact them, offer people as well so we can go there. So I need to, this week, from now to Wednesday. So for now we have to plan. I don't know whether you have a set of questions that you would be asking them. Have you done the set of questions?

A: Yes, I have for different kinds of people I have different sets of questions.

S: Okay. So if it is ready, then let's see today, tomorrow, and see whether by Wednesday we can go out there to start. And then we will be able to do the interview.

A: I talked with Esther and Lindsey that they also said that it's important maybe that the target group or the farmers I talked to are also the farmers that would be willing to invest in something like that. So they are open to maybe adopting packaging or they already have some packaging that it would also be good to speak to some farmers that don't do packaging and some that do, because then I can really see what the choices are from people.

S: So why some people choose to do packaging and why some people are like, no, I don't do packaging.

A: Yeah. So I think a variety of people is really nice because I also heard that some people harvest the produce and then the market women come and they take the produce to the market. But I also heard that there were some people they take, for example, their own produce to the market or the supermarket. Yeah, so I think that's also a lot in Charlotte's report as well, like the roads to market. But I think that's also really nice to hear from the farmers where they do that.

S: I'm trying to call some people.

A: Okay. Yeah. So and I was wondering if you maybe know for the like the lead farmers connected to the college, where do they sell most of their products? At the supermarket or at the market or to restaurants. Because I didn't go to the markets yet, but when I was in the bus, I saw some like markets on the side and then I saw that most of the fruits and vegetables, they were not packaged. But I think it was maybe apples or something or it was like they were they were packaged in plastic in like rows of four.

S: So for them, they do do the packaging for the markets, which is yeah. If you do you know anything about that or. Sometimes most of the fruits and vegetables that we sell, they are not packaged. It's probably the supermarket that you go and see that some of them are packaged.

A: And do you know if the supermarket packages them or if the farmers do it themselves?

S: Sometimes they contacted the farmers whom they are working with to package before they bring. So that's why I'm saying that it may be for those in commercial and those that are in the greenhouses. Yeah, and maybe it's also good maybe because sometimes maybe it's not at the market is less necessary. They could also be or that it's more difficult to arrange packaging for the markets than for the supermarket. So you kind of have to see that as well.

A: How does the process go like from harvesting to that it gets sold? So like from harvesting to consumer.

S: Normally what the farmers are going to do is, is the time of harvesting that they consider. The type of weather for their harvesting. If it is lettuce, they need to harvest early morning, around 5 a.m. to 6. Or 6.30 because of the sun. They harvest early. And then also harvest the perishable one, very tender one. They harvest around evening by 6 to 7 or 5 when the sun has gone down and there's no temperature, they harvest it and then transport it in the night. In the evening, yeah, in the evening rather to the point of sales. So it doesn't perish.

A: And those are? Like lettuce?

S: Yeah, the leafy one, leafy vegetables. They are cabbage and those that easily perish. But the rest they can harvest at any time like the fruit one, fruit like squash, that is a squash, cucumber, they are fruits. They can be harvested at any time. Because they are not easily perishable. All the leafy vegetables are harvested in the morning and in the evening. And then they also like to transport them in the cold weather. Because they don't have a cold chain system to be able to control the temperature. And so they have to harvest in the time that the weather is not too hot.

A: And do you know how they transport them? Yes, some of them are put in polybags. Like this. Bigger one. Some of them are put, some of them are squashed in there. And then they are transported to the market. Some use sacks. Some use sacks for fiber, polysacks. And then they put, they pack them in it. And then they take it to the market. There's no cold system like in a van, a cold van for transportation now. So they only transport it at a time when the temperature is not too high.

A: So what is the most, maybe the most grown vegetable, if there is any, or if everything is kind of grown equally, or what's the sold the most?

S: For here in Kumasi, what they grow most is spring onion, cabbage, and lettuce. This is a common vegetable that is mostly grown in Kumasi, around Kumasi.

A: Because of the ground and the conditions, or just because people eat it the most?

S: Yes, people eat it the most. And then they do well here. They don't mostly grow tomato here. Going to the northern side, that is where they normally grow the tomato.

A: Because it's better there, or because they eat it more there?

S: Because of the... they eat it more in the south, but it is not.. we don't grow it in the south here. The weather and then the soil doesn't... it's not the weather, I said, but I don't know whether it's the weather. We are still researching into that, the soil or something. So we normally have a few diseases that are affected by tomato. I think its humid condition of the environment. Sometimes it's very humid, which attracts or which finds itself inducing from those diseases. So we don't normally... it's grown here. I'm not saying it doesn't grow at all, it grows. But it is not a crop that farmers usually do, because it's difficult to do it here. Unless in the greenhouses. So most of the times we import the better from the northern side and then from our neighbouring border, Burkina.

A: Ah, yes. So you import them from other countries. And then the tomatoes growing in the northern part of the land.

S: Yeah. So then it has to get transported all the way to the south. Most of the local ones are being planted at this side to the northern sector. Bono, Northern and upper. So these are the three regions that tomato does well there. The bono region, the northern region, and then the upper region. The upper region, they use irrigation mostly because they don't have much rains. So they use irrigation. They have a dam which they use to cultivate their crops.

Conclusions meeting

- ACHI manager will arrange the right contacts for me in order to visit the suitable farm and speak to the right farmers
- Most fruits and vegetables in the local market are not packaged, the fruit and vegetables that are sold in the supermarket are mostly packaged. Most of the time the supermarket will ask the farmer who supplies to them to package the produce or the supermarket does it themselves. The ones that sell to the supermarket are usually the more commercial farms that may also have greenhouses.
- Harvesting of perishable vegetables such as leafy vegetables are harvested early in the morning or in the evening and transported when it's dark. The sun is down and the temperature is lower at those moments which prevents the vegetables from going bad very quickly.
- These vegetables are transported in plastic or fiber sacks, where the vegetables get damaged or squashed easily.
- In the Kumasi region the most grown vegetables are lettuce, cabbage and spring onions. Tomatoes are sometimes grown but the climate or soil around Kumasi is not good for tomatoes because of the humidity which makes them more susceptible to diseases. Tomatoes are imported or grown in the northern region.

1.5 Meeting Project coordinator ACHI Ghana

26-04-2024

Project Coordinator for ACHI in Ghana at KAC

The conversation is about prices in the supermarket and demand of vegetables for different consumers.

Meeting summary

The prices for bell peppers are significantly higher than other vegetables, The ACHI project coordinator Ghana says this is mostly because of the demand. Overall people want to buy the best quality, most healthy vegetables, which is usually more important than the price. It does depend on the social class people are in and what capacity they have to spend. So higher classes with more money would be more likely to go for the best quality, big vegetables which have a higher price while some lower class people who have less to spend care less about the quality and more about a cheap price. Overall people perceive vegetables that are packaged of higher quality and more healthy. If a vegetable is packaged it means that it went through processes such as cleaning and sorting which is perceived as less possibility of contamination which is perceived as more healthy. In Ghana, there is a lot of dust so unpackaged vegetables are more easily contaminated. So especially for the people of middle and higher classes, they are willing to spend more on quality which means they are willing to spend more on packaged vegetables than unpackaged vegetables. Next to the perceived quality of packaged vegetables, they are usually also traceable. So usually there are contact details on the packaging, this allows for consumers to know where the produce comes from which helps in determining the quality. They can maybe visit or do an online check.

Adding packaging with contact details that allow for traceability can sometimes also be a barrier The ACHI project coordinator Ghana says. When adding contact details you are also traceable for people of the government performing quality checks to meet standards. If your produce is for example available in the supermarket the inspection might do random checks, so they take your vegetables to the lab to run tests on the levels of chemicals or metals. If it is the case that the levels are too high they can trace the vegetables back to you and there is a risk that you are out of business. This means that for some farmers adding packaging can be a risk because of traceability. They prefer to sell to the market and stay anonymous to not risk being taken out of business because of not meeting standards. This also adds to the perception that packaged vegetables are healthier because farmers are prepared to meet the standards.

Conclusions conversation

- Packaged vegetables are perceived as higher quality, more healthy vegetables because it show that it went through several processes to get cleaned and sorted before packaging. Next to this the products are usually traceable because of contact details, this allows for a check and also means farmers are prepared to meet vegetable standards.
- Traceability of vegetables can have risks. If you are traceable checks for quality standards can be performed which can have consequences for your business.

1.6 Meeting Packaging expert KIDV

25-03-2024

Packaging expert at Netherlands Institute for Sustainable Packaging "KIDV"

Keeping vegetables fresh

What can you do to extend the shelf life of vegetables (storage, transport, climate)?

- Bundling, for transport storage and then especially damage, which makes it rot faster. For not getting damaged by its own weight.

Are there classifications within packaging for different types of fresh vegetables?

- Onions and potatoes absolutely not airtight, neither are tomatoes, others are. Condensation comes in closed plastic bags, for some vegetables higher risk of rotting. For cut vegetables, it's different again because then there is an internal climate. Packaging also for identification, laser identification on the skin (apple not, courgette)

Are there known techniques that are suitable for warmer, more humid climates, do you have experience with them?

- With coffee, they actually make use of it, think canopy, sun or shade. Especially pests, even elephants can sometimes be the reason for losses. The riper the more vulnerable, because softer. Stack height is especially very important.

Packaging of fresh vegetables

What forms of packaging are used for fresh vegetables and which are best for keeping vegetables good for the longest time?

- Depends on each vegetable. Paper trays often have a lot of plastic in them to avoid moisture. But paper needs more of it unprocessed so is it more sustainable then? It is a moisture-sensitive chain, so just using paper is difficult.

Some vegetables are packaged differently in different shops, what is the main reason?

- Convenience has to do with it. More customer-oriented, bucket can be resealed more often, so more convenient for cherry tomatoes, large tomatoes handle more in one use

What are sustainable forms of packaging and which ones are there?

- It's all about the combo of packaging, product and context. Reusable packaging is very good in terms of the system, but if there is too much distance or effort to get the packaging back, it doesn't work out.

What are the cheapest forms of packaging and the cheapest materials?

- Plastic bags in general. There is an African country where bags are banned, litter is a problem. Asia doesn't do it as a country yet either, there is a lot of litter there too because they don't know what to do with it. Indonesia packed with leaves, they just threw that on the ground, then packed with plastic and thrown on the ground is

seen as prosperity. DOCU (steel). Perception of evil, it's a new perception of a problem that people don't know about.

The Machine

How does the type of packaging affect the method of packaging? (The machine)

- Efficiency can work, standardised process for large production. Hand packing can again be more convenient for smaller production, also to save packaging material for smaller or larger products. By hand, you can do more sorting steps. You can make people proud of the product so they value it more.

Conclusions meeting

- Most important aspect of packaging for keeping vegetables fresh for longer is to bundle them in order to prevent damage which will cause vegetables to go bad sooner.
- The best packaging is influenced by the produce, packaging & context combination and therefore different for every situation. Some vegetables can be packaged airtight while others rot faster because of condensation. Also sun vs. shadow.
- The riper the produce the more fragile it is and the more stacking height is of importance.
- Overall packaging of fresh vegetables is very moist sensitive.
- Depending on business size and helping hands a more standardized or hand-led process can be optimal. With hand, you can save more material and can make more sorting steps.

1.7 Meeting Post-harvest technology department KAC

14-05-2024

Teachers in post-harvest technology at KAC. They teach students about the stages of plant crops before, during and after harvesting and how to handle them after taking them from the plant. This includes the treatments it goes through and storage practices. This does include the basics of packaging in bulk for storing and transport, but is mainly about the use of the bags and crates. The meeting with teacher 1 is recorded and transcribed, after that there was a quick meeting with teacher 2 that was not recorded and is therefore summarized.

Meeting transcript teacher 1

A: So I think I told it last time a bit already, but I'm doing a project here for my graduation project. So I've been researching for the past five weeks and I've been mainly looking at post-harvest losses and then in combination with packaging. So if there's any packaging solution I can design or introduce that will help with reducing post-harvest losses. So therefore I was also curious about what you teach here about like the post-harvest handling and stuff like that. So I was wondering maybe what your department is and what you teach the students here.

R: Okay, so there's post-harvest technology. Yes, so if you look at the handling process there are a number of activities that you need to give probably the produce before you package it. And it is dependent on the particular produce. That's why the last time I came I was asking you are you actually working on a particular produce? So probably you look at perishables.

A: Yes, it's fresh vegetables.

R: Yes. But they easily deteriorate if proper care is not taken. Especially if you look at them, if you don't give them proper handling as to the correct temperature, the correct packaging material, the produce would probably deteriorate. So we just look at ways to decrease the temperature and then cause the produce to prolong its shelf life. That is what we basically look at. Then when we finish we also talk about the storage, how we are going to store the produce. So basically the unit time, first of all, we look at what post-harvest technology is all about. We look at the importance of post-harvest. You know post-harvest means after you harvest the produce. So after right after detaching the perishable from its parent plant, what are the processes you undergo or the activities you give to the produce before you store them. And when you talk about the processes you give to them, look at the technology. What technology can you give to the produce so that it can prolong the shelf life in order

to prevent losses? Okay, then we talk about types of losses. We look at the different types of losses. Losses are actually the direct loss and then the indirect loss. So we look at types of losses. Then we come to the perishables itself. We look at the stages, we look at the process that every perishable and so for instance we have the developmental stage of the produce, the growth stage, the maturity stage. At what point do you even have to detach perishable from its parent plants. Then we look at the, when you talk about the maturation stage. So we have some criteria that you use to identify whether a produce is matured or not. So

these forms the process of the stages of perishables. Every perishable undergoes the development stage, the growth stage, the maturation stage. And then the ripening stage before the ripening stage. The time of the ripening stage means that the produce has got into its ripening pitch so it starts to decline. It starts to decline back and then you look at methods of assessing the quality of the produce. These are the things we teach there. Then we come to look at the treatment you give to the produce after it has been harvested. So for instance, the moment you detach the produce you would have to reduce or take away some heat because temperature is an environmental effect that causes rapid deterioration in foods and vegetables. Yes, the most important to avoid the virus. Temperature, the climate, the time and then temperature, time. All these external factors that affect the produce. So you need to reduce some heat from the produce. So probably you can do pre-cooling. So you pre-cool the produce so that it takes away the heat. Then you can sort first to take out the ones that have gone bad and then so you grade them. Then after grading you can sort them. So after sorting them you can give them the treatments that they need. For instance, if it is orange citrus fruits you can use chemical before you package it to the markets. So basically these are what we look out for. Then right after packing we can do labelling and so on and so forth. After then with the cereals and legumes and others we actually discuss how we can store them. So that is it about post-harvest technology.

A: So your course about looking at all the things before and during harvest and the treatment after. But I think maybe the packaging of fresh produce is something that maybe falls without your course or is it also within the course to do packaging of the fresh products. Maybe do you teach them anything about using proper crates or bags or something?

R: Okay so that is one. You have to include, maybe we can have a discussion with the home science department. She actually did a masters in food science. So with the materials you need to package, I mean to her, packaging materials. So packaging really has the concept. But generally yes, for instance something like tomatoes. Here it is very safe to use boxes or it would be in some form of crates.

A: So that's like the wooden ones right?

R: Yes, in that wooden ones, box wooden ones. So that it is perforated, air circulates so that we will prevent heat build-up from the tomatoes. So boxes are a good packaging material for tomatoes or even the perforated baskets.

A: And the boxes they are made from? Like what material are the boxes made of? Are those from the wood?

R: Yeah wood. And then the other vegetables they go in that right. I think we can also use plastics. So once it is perforated, so if it has access to air, there is amount of air waiting or taking away heat, it's fine. That's why my concern was are you actually looking at a particular produce so that we can give the outline? Because if you talk about foods and they go up perishables, it's a whole lot. So probably the packaging material you use for tomatoes

wouldn't be the same packaging material you use for probably onion. So you need to look at, if you are taking like let's say three perishables, probably tomatoes, maybe carrots or something, then you look at that into details. But if you generalize it, then yes, that's where the difficulties come. So I think... Because it is not the general, it is not the same.

A: No, I think I'll likely maybe be looking at either tomatoes and then there are crates I think or at the bell peppers. I think those ones, I've not officially chosen focus but either one of those I think I will focus on.

R: Okay, sure. So you need to look at one perishable so that we can actually have a soul idea. So as it stands, I would want to know which of the perishables or the produce you want to work on. Then we look at the whole steps. Yes, then I will check the material. From the harvesting to the treatment we should give to it before we package. Then we look at the packaging material that would be best for the tomatoes. And then how long it shelf life. So maybe we can set the objectives. We look at the losses aspect and then the shelf life and the packaging material that would be best for storing tomatoes. And even for the peoples of transportation, the packaging material that we best with that it doesn't have this cohesion. It doesn't add to each other for breakages and breaches and bruises. So that would be best if we can get one particular or look at probably two or one produce that we can't work in. Because if we generalize it's like perishables.

A: Yes. So then for tomatoes what would you say, like what do you teach the people here about tomatoes?

R: So we actually generalize it as you are saying. But when we take one produce and maybe we can read more on tomatoes alone. So yes, I can look at that area too for you. So probably in tomatoes, tomato is highly perishable. Very high. So probably it should be in the states where we will not harvest it's where because it's a climatic fruit. So when we detach it from the parent plant it will still ripen even if it is not with the parent plants. So we have to look at the time that we need to harvest it so that it will not be overripe it. Then we look at the treatment that we best for the tomato so that it can grow longer shelf life. Then we have to look at the packaging material that we need to use for the tomato so that it doesn't deteriorate fast. But we also have to look at the shelf life of tomato it's probably a week or two. I mean it can't be there in the environment for about a month. Because it's highly perishable. So I think we can look around tomatoes because it's highly perishable. Or probably we can also look at the green pepper. Green pepper it's not as high as that of the tomato. The only challenge will be the fact that it will lose a lot of water. So the surface will start to shrink. It won't have a smoother surface. A shiny new surface. So something like green pepper you can during the course of the processing you are giving to the materials you can polish the surface, work sets so that it can conserve some amount of moisture. So if I know you are working on tomatoes then we can read a lot about tomatoes. If it's a green pepper you want to work on then we can start from. So the treatment that we are giving to green pepper before storage. Then we look at the suitable packaging material for green paper. I think that will help. Okay, that's a good one.

A: So yeah I was wondering because do you also walk through it with students like this? What packaging material would be good for it or is it something that's maybe not in the course?

R: Yes it's a component of it. So for instance when you take, but we don't really go into detail because it's a diploma level. So for instance when you take something like maize ideally we tell them that the best packaging material for maize you can use the sack. Yes then you give the reason and the reason being that it's maybe probably so so and so. So we don't really dive into details. This is just a diploma level. So they know, if you ask any students here what is the best packaging material for tomatoes they can tell you it could be box, it should be a box. I think it's one of the questions that they ask. When I ask questions I do ask them what packaging material is suited or best for particular produce and I'll give them alternatives then you can select one. But so with the packaging material myself I can even ask for the home science department.

A: I spoke to the home size department. So that was really good. She told me also about stuff. I was also wondering, because you said like the grading and the sorting, is it also like do you also teach something about washing them or is it like cleaning?

R: So just as I said, so one point, before you package the process that you need to, the activities that you have to give to the produce before you package them. So I said, I talked about pre-cooling. Then maybe you clean before you, if you want to preserve it, you add your chemical on it before it goes to the market. So that's the process.

A: In the cleaning, I can imagine it's also different for different vegetables.

R: Oh yes. There's so many you do with washing. Some you just have to, you don't even need to. Mostly some of them you have to use brush. So some you can wash. Because if you do that, some you don't wash them and you can't wash them, otherwise it will deteriorate fast. If you add it to water something like onions. The moment you put onion in water, it will deteriorate fast. So if you add the moist onion to the dried one, it will cause the whole thing to spoil to deteriorate.

A: And for the tomatoes and the peppers, it's brushing both, or is it with water?

R: Tomato, you also need to conserve water. So you wash them. You can wash it. The tomatoes you wash and the pepper you brush. It depends. You can wash them, but you make them dry afterwards. Something like garden egg. If you wash garden egg, it won't even last for a week. It will spoil. It will go bad. So we don't wash them. Brush them or clean it. But so what will help me is that let me know the amount of produce you want to work on. I mean, we can do this together. Then I can also help you in that way.

A: Thank you very much, Thursday I am going back to the Netherlands but let's exchange numbers.

R: Ah yes.

A: Thank you very much for the conversation.

Meeting summary teacher 2

The conversation was about all the stakeholders I spoke to in the past weeks and the focus that would fit with different stakeholders or not. We spoke about several directions to go in when designing a packaging solution and what would and wouldn't work. Designing a retail packaging solution used for the local market would likely not work since either farmers or market women would have to invest in it while it will not be a great benefit. Maybe you could sell it for a little more but most people would still buy unpackaged. So retail packaging would be a suitable option for the supermarket. Still it would need to be simple since complex technologies such as for example ethylene management would cost too much for the current system in place. When looking at a solution that could work for the local market supply, looking at transport solutions would be a good option. Adding a simple solution to the existing system and containers could have impact for a lot of people. You can think of liners for the inside of crates, padding layers in between produce and options for allowing ventilation. Plastic crates would also be a good option but it would be expensive and hard to fit into the system, it would require a whole system to change which is hard. Next to supply of the local market this solution could also work in other situations.

Conclusions meeting post-harvest technology department

- In the post-harvest technology course at KAC they teach the handling of vegetables pre and post-harvest up until the point of proper storage and bulk packaging. It is still general since it is a diploma level education to they do not go into really deep details per vegetable but teach the overall knowledge. It includes reducing PHL and extending shelf life.
- They teach about reducing heat, cooling right after harvest. Then they teach processes of sorting and grading to prevent faster decay. Also cleaning is a part of the course. This is different or every vegetable, depending on that you brush or wash and/or dry. After that other treatments can be applied.
- A good focus would be transport packaging since it would have impact for a lot of people and is a problem that the farmers and market women would be motivated to tackle. It should however be very cheap and simple otherwise it will not work.

1.8 Meeting Home science department KAC

07-05-2024

Head of home science department at KAC. The home science department teaches students about processing, packaging and labelling. This mainly revolves around packaging of processed products rather than fresh ones.

Meeting transcript

A: Good afternoon. So, as the last time I told that I was looking at packaging and a bit in combination with reducing post-harvest losses through packaging. So we've been going to farmers for the past weeks and we've been to markets and stuff like that, and the supermarket to see a bit how it currently happens. And what I was now mainly curious about is what you teach here at the college, kind of around that topic. So maybe packaging or post-harvest handling or stuff like that.

J: Yes, so for, I don't know if you are aware that we've been teaching on the UCC program, the University of Cape-Coast program and also KAC program. So in KAC, I teach the final year's course and part of the course is food product development. So it's the food product development area that we look at, processing, packaging and also labelling. So for the packaging, then we look at the various types of packaging and we go through the processes of selecting the best packaging material, depending on the product that you want to package. And with that, in selecting the packaging material, you should have that prerequisite knowledge and the factors that contribute to post-harvest losses. Because those are the factors that you want the packaging material that you choose to be able to help you to reduce those factors in order to extend the shelf life of the product. So that is for the new food product development.

A: So that is the packaging you look at, I think mainly also for the processed foods, right? Or is it also for fresh foods?

J: So it depends on whichever way you want to go. It's general. It covers all. So that if you are, because of why we say food product development, we are looking at coming up with a totally new food product and packaging it or an existing product which is not properly packaged. So you find a better way of packaging in such a way that it will attract the customer. And it will also be an existing product that you want to extend the shelf life. So this existing product that we are talking about could be one of these highly perishable cultural produce or a processed one. So it's the product that will determine the kind of packaging material. And it will determine the condition and the which it should be kept.

A: And is it, when you do the course, is it also that the students, they maybe pick a product themselves and then they improve the packaging of it? That's what you do in the course, right?

J: Yes. For now, because of time factor, what I do is I give them an assignment in that area. So for instance, tomorrow we are thinking of showcasing the packaging materials that we have here, the basic equipment that we have here, as something like an exhibition outside.

So they will come around to observe. Then we have this stage of product development, we call ideation stage. So that when they come, knowing what is available, then they will go and sit down and brainstorm, think about a product that they want to come up with. So that if they want to start from scratch, process, come up with a totally new product and package it, the equipment that they see around, will they be able to help them to achieve that. Then the packaging, the ones that we have here, will they get some that can help to package that particular product. Because the assignment is said that they are supposed to come up with a package product that can be showcased in the supermarket on the shelf under room temperature. So it comes with, should I say, a format that you are supposed to follow. So that after the exhibition, then they are not going to sit down, they are going to work in groups. Then that is when they will come up with their product, what packaging and submit it.

A: And that happens in one day or the assignment takes longer?

J: It has a timeline. Because before they present this, myself, we are going to have practicals after the exhibition. They will be having their May semester from next next week going. So I want them to finish with their May semester. Then we move on to product development, where they will come here and we do the practicals. So we prepare some juice and pastry products, then some of these household detergents, like you can smell. And for those ones, we get the packaging materials and everything for them. So when they finish, we package. So that one, we are going to do it with them. Then after that, then with their ideas, they go and do their own thing and come and submit. So they first experience other things and then they get there.

A: And then what kind of materials do you have laying around?

J: SO, for this one, it's just for food of the canteen. But then, somebody can improvise and use even this one to package something. So it's about their own creativity. So you look at the things available. We have some packaging materials like these ones. We have a number of them.

I guess we have these ones. If something like coffee is that you want to go in, develop coffee, these are the packaging tools. So we have different packaging materials and we already have this one for instance. We have the last one, so we can teach them how to package and import sizes. So that's what I am going to do today. I'm going to showcase some of his tools for them to just see.

A: I was wondering because I think what you teach is also mainly more about the processing and creating like, like you say, a processed product that can be on the shelves. Have you ever done anything packaging of fresh products? Like the fresh vegetables or fruits?

J: Normally we do something to the fresh produce before packaging. Because most of the times I'm much concerned about the shelf life. If you package and fresh them. So we have a dehydrator there. If you realize that the produce contains a high amount of moisture and it can be a challenge. Then we put it in the dehydrator to reduce the moisture content. Then after that you can just package.

A: Yes, because the problem maybe with packaging the fresh ones is that it's...

J: That if you package it in a plastic bag, that it will be a little more moisture inside and it will spoil faster. And for that one, that means you will need a cool temperature. To reduce the high amount of transpiration rate and also respiration of the vegetable since it is alive. Yes, you need like the ventilation and colds. So that if such fresh produce, you want to market it at a certain place. Then it should be at the shopping mall where they have the air condition. And the cooling systems. So that even if you package it, it will take a bit longer.

A: Is that also what you teach the students here in the packaging course?

J: That's why I said, you see the course content for the product development is narrowed down. With the assumption that there's another course, I say post-harvest handling of agricultural produce. It's a course on it too. And by the fact that that can affect the quality of the product. And also the condition and the way those products should be stored. But that is taught here by someone else, by the engineering department.

A: Yes, right. Because I also want to speak to them again. Yes, you said something about the labelling. Um, because I can imagine it's a bit different for processed products and non-processed products, but what do you teach them about that? Like what's important to put on a label?

J: First and foremost, we have the rules and regulations governing and labelling of a packaged product. So when we get you packaged, then you have to put your label. And when you put your label, there are information that are needed on it. So that for instance, if it's a fresh produce, you should have a fair idea of how long it can keep and what temperature. And the condition and the weight should be stored. This information should be on it. And the company that is, or the person who produced that particular product, the name must be there. The address must also be there. Then we have what we call the batch number. So that for the first badge, you have a number there. And this helps if you want to conduct a tracer studies, if you want to trace when the product has gone to. Then for some products, you also need the barcode. Then either the best before or expiring date. And also the usage. There are some products that, when it's covered like this, you can keep it at the room temperature. But immediately it is opened, you have to keep it in the fridge. So these instructions must be there. And if there are any, should I say any ingredients in the product that can contribute to allergy reactions, it should be spelled out on the label for whoever takes it to know. So these are some of the things that you consider and I even have some labels already developed. So the ingredient that you use must also appear. If it's about nutrients, the nutrients that the person will get after using the product should also be on your label.

A: I was also wondering because some of the fresh vegetables they are sold to the market women in Kumasi. Do you also do some processing here at the college and sell the product or is it more like the teaching of it and that people can do it if they want to go in business?

J: We haven't started that. I remember there was a time we were thinking about doing that but you see this place has become more or less like a training institute and when the students are around that is when you see activities, when they are out then it becomes a bit of a challenge. Normally when the product is on the platform that we have this particular thing available then within a short time everything is finished. So if we were to be facing that challenge of most of the produce going down the drain through post-harvest losses then home science would step in and find a way for the tomatoes to convert to tomato paste at least for the student can't eat so that they can. But so far we haven't had that kind of challenge. So they put it on the platform and if you are interested you just call and you get your package.

A: Okay, nice. Yes I think maybe that's all my questions for now or I think I know everything. Yes because I had some questions about the other questions I'm going to ask to the post office. It was very nice. Thank you very much.

Conclusions meeting home science department

- At KAC they teach packaging practices of processed produce. They teach how to find a fitting packaging material that will extend the shelf life of the product inside and prevent post-harvest losses.
- They currently don't teach packaging of fresh vegetables because it is challenging in combination with shelf life. When packaging in plastic moisture content is a difficulty and overall the lack of cooling facilities is a barrier when packaging fresh produce and next to this proper ventilation is important for fresh vegetables.
- When labelling produce it is important to mention: storing instructions and time, best before date, company name, address, weight, barcode, batch number, ingredients, nutrients, allergy information.

Appendix 2

Research questions

Below the main research questions with their accompanying sub questions are stated.

What does farming in Ghana look like for commercial smallholder farmers?

- Who are the commercial smallholder farmers in Kumasi?
- What do commercial smallholder farmers grow?
- How and why do commercial smallholder farmers grow vegetables?

What does the fresh vegetable value chain look like from farm to consumer?

- Who are the players in the value chain and what are their relations?
- Where do post-harvest losses occur in the value chain?
- What are current packaging practices for fresh vegetables in Ghana?
- What processes do vegetables go through before reaching the consumer?
- What does the Ghanaian consumer pay attention to when buying vegetables?

What do post-harvest losses look like in Ghana?

- What are reasons for post-harvest losses in Ghana?
- What is the magnitude of post-harvest losses of major vegetable crops in Ghana?
- How can post-harvest losses be tackled by packaging?

What is the best-practice vegetable handling for extending shelf-life?

- What factors contribute to vegetable deterioration?
- What are optimal vegetable conditions?

What are packaging practices for fresh vegetables?

- What are the currently available packaging solutions for fresh vegetables?
- What are reasons to choose for packaging or not?
- What is the impact of packaging on the environment?

Where in the process between harvesting and retail is it best to introduce a packaging solution in Ghana?

- What are challenges around packaging in Ghana?
- What are the reasons or barriers for people whether or not to adopt packaging?
- What are the available resources in Ghana for a packaging solution?
- What opportunities can be identified around packaging in the context of Ghana?

Additional research questions after choosing a focus

How can banana leaves be used as a packaging material for fresh vegetables in Ghana?

- What perception do Ghanaian stakeholders have of banana leaves as a material?
- What is the availability of banana leaves in Ghana?
- What material properties do banana leaves have?
- What are examples (in packaging) of what banana leaves are used for?

Appendix 3

Research preparations

3.1 Interview guides

Interview guide (lead) farmers

Introduction

- Name, profession
- Farmsize & employees, what do they do?

Farming & post-harvest losses

- Which crops do you grow & why? (most grown, year-round variation & choice)
- What does the process from harvest to market look like?
 - o Harvesting (who, when, how (basket?))
 - o On-farm treatment (cleaning, sorting, packaging or storage vessel)
 - o Storage (available, where, how, container, how long)
 - o Transport (who, what vehicle, how long, where to)
 - o Market (who, sorting, display, selling)
- Do all harvested vegetables reach the market? (How much, where most loss, why)
- Do you take any measures to extend the shelf life of your produce?

Business & prices

- How do you sell your produce and to whom? Why to them?
- What price do you get for the produce? How do you decide on the price?
- What is your profit for vegetables?
- Do you get a better price for better looking vegetables?

Packaging & marketing

- Do you or have you considered to use packaging for your product? Why/why not;
 - o Do you see benefits of packaging produce?
 - o How much does it cost?
 - o What do you use to move the vegetables (on-farm, transport etc.)
 - o What packaging is used?
 - o What would you want packaging to look like?
- Do you know of other farmers packaging their produce?
- Do you see much packaging for vegetables?
 - o Where and why?
 - o What does it look like?
 - o Which materials are being used?
 - o Who does the packaging?
- Do you use any form of marketing to promote your produce?
- If packaging (differently) could maintain the quality of vegetables and extend their shelf-life, would you adopt it? On what conditions? (time, effort, money etc.)

Interview guide vendors (supermarket & market)

Introduction

- Name, profession, duration

Supply, handling & post-harvest losses

- Where do you source your vegetables from? Who are they?
- What crops do you receive and how do you receive them? Who does transport?
- What does the road from farm to (super)market/consumer look like?
 - o Farm (storage, handling/treatment)
 - o Transport (who, what vehicle, how long, where to)
 - o Market (who, sorting, display, selling)
 - o Storage (available, where, how, container, how long)
- In what quality does the produce arrive?
- Do all vegetables reach the market? Are there losses? Where and why?
- Do you take any measures to extend the shelf life of your produce?

Consumer & selling

- How do you display vegetables? Conditions, bundled, weighted?
- How do you decide on the price for the produce with the supplier?
- What do you pay the supplier?
- Do you pay more for better looking/better quality vegetables?
- What is a good quality vegetable? What does it look like?
- How do you decide on the selling price of the vegetable? How much is it?
- What is the profit for vegetables?
- Can you ask more money for better quality vegetables? How much?

Packaging & marketing

- Do you sell any packaged vegetables? Why/why not?
 - o Who does the packaging?
 - o For how much more?
 - o Do you see benefits of packaging?
 - o What would you want packaging to look like?
- What is used to move the vegetables around?
- Do you know of initiatives to package produce?
- Do you see much packaging for vegetables?
 - o Where and why?
 - o What does it look like?
 - o Which materials are being used?
 - o Who does the packaging?
- Do farmers use any form of marketing to promote their produce?
- If packaging (differently) could maintain the quality of vegetables and extend their shelf-life, would you adopt it? On what conditions? (time, effort, money etc.)

Interview guide consumers

Introduction

- Name, profession

Buying

- When buying food, do you buy vegetables? Which ones?
- Where do you buy vegetables? Why there?
- What do you pay attention to when buying vegetables?
 - o Price, value for money
 - o Quality, weight, size, bruises, damage
 - o Health benefits, safety, pesticide use
 - o Bundled packs or separate?
- What do you pay for the vegetables? What do you pay more for?
- Does packaging matter to you?

Packaging

- Do you ever buy any packaged vegetables? Why/why not?
- Do you want to pay more for good quality packaged vegetables?
- What packaging would you prefer if you would buy packaged vegetables?
 - o Materials/visibility of the produce
 - o Marketing/information
- Do you see much packaging for vegetables?
 - o Where and why?
 - o What does it look like?
 - o Which materials are being used?
 - o Who does the packaging?
- Do you look at marketing of products? Labels, stickers, does it matter?

Interview guide KAC staff

Teaching at KAC

- Name, profession, previous experience (on farm?)
- What do you do at KAC? What do you teach?
- How do you teach? What materials? What works best to get the message across?
- What is taught at KAC about extending shelf life of vegetables? Handling/packaging?

Personal farming experience

- Do you farm yourself? Which crops do you grow and why?
- Do you sell the crops?

Farming & post-harvest loss at KAC

- What crops are grown most often & why?
- What does the process from harvest to market look like?
 - o Harvesting (who, when, how (basket?))

- On-farm treatment (cleaning, sorting, packaging or storage vessel)
- Storage (available, where, how, container, how long)
- Transport (who, what vehicle, how long, where to)
- Market (who, sorting, display, selling)
- Do all harvested vegetables reach the market? (How much, where most loss, why)
- Do you take any measures to extend the shelf life of your produce?

Business & prices at KAC

- How do you sell your produce and to whom? Why to them?
- What price do you get for the produce? How do you decide on the price?
- What is your profit for vegetables?
- Do you get a better price for better looking vegetables?

Packaging & marketing at KAC

- Do you or have you considered to use packaging for your product? Why/why not;
 - Do you see benefits of packaging produce?
 - How much does it cost?
 - What do you use to move the vegetables (on-farm, transport etc.)
- Do you know of other farmers packaging their produce?
- Do you see much packaging for vegetables?
 - Where and why?
 - What does it look like?
 - Which materials are being used?
 - Who does the packaging?
- Do you use any form of marketing to promote your produce?

Interview guide HGT staff

Working at HGT

- Name, profession, previous experience (on farm?)
- What do you do at HGT?
- What knowledge does HGT have/spread about extending shelf life of vegetables?
Handling/packaging?

Personal farming experience

- Do you farm yourself? Which crops do you grow and why?
- Do you sell the crops?

Stakeholders

- With whom do you collaborate/work in Ghana? KAC, farmers, etc.?
 - What kind of farmers?
 - What is the difference between them?
 - What does farming for those farmers look like?

Farming & post-harvest loss

- What do farmers grow? Why & when?
- What does the road from farm to consumer look like for different farmers?
- Do all harvested vegetables reach the market? (How much, where most loss, why)
- Do farmers take any action to extend the shelf life of their produce/maintain quality?

Business & prices

- How do farmers sell their produce and to whom? Why to them?
- What do the prices and profits for vegetables look like?
- Do you get a better price for better looking/better quality vegetables?

Packaging & marketing

- What is used to move the vegetables around?
- Do farmers consider using packaging for their product? Why/why not?
- Do you know of any farmers packaging their produce? Or other people?
- Do you see much packaging for vegetables?
 - o Where and why?
 - o What does it look like?
 - o Which materials are being used?
 - o Who does the packaging?
- Do farmers use any form of marketing to promote their produce?
- Does HGT provide any information about shelf-life, handling, packaging or marketing?

Interview guide for people that are packaging

Introduction

- Name, profession

Packaging materials

- Do you see much packaging for vegetables?
 - o Where and why?
 - o What does it look like?
 - o Is there marketing on the packaging?
 - o Who does the packaging?
 - o Is there a preferred form of packaging?
- What packaging materials are used?
 - o Which materials are being used?
 - o Where is the material sourced from?
 - o Are there any materials that do/do not work in this context?
 - o What is the price? What is the cheapest?
- How does the packaging happen?
 - o Manual labor, tool or machine?
 - o What materials are used for a tool or machine?
 - o Where can you get these materials?

3.2 Observation guides

Farm observation

Name:

Info:

Date:

Harvest handling

Conditions, vegetable container, handling



On-farm treatment

Conditions, cleaning, sorting, packaging, vegetable container



Farm storage

Conditions, duration, vegetable container, handling



Transport

Conditions, vehicle, vegetable container, handling



Market/supermarket observation

Name:

Info:

Date:

Storage

Conditions, vegetable container, handling



Processing

Conditions, sorting, packaging, bundling, vegetable container



Selling

Conditions, display, price, vegetable container, handling



Transport observation

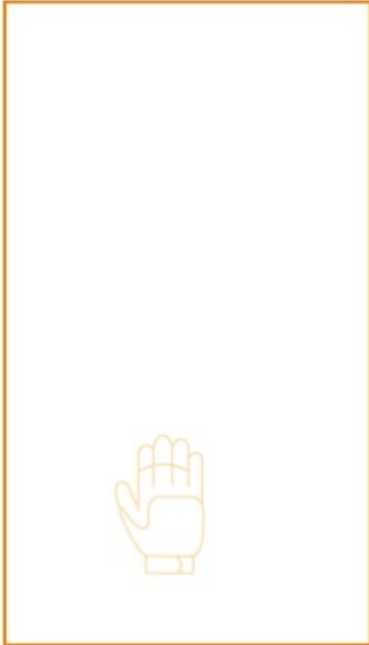
Name:

Info:

Date:

Loading

Conditions, vegetable
container, handling



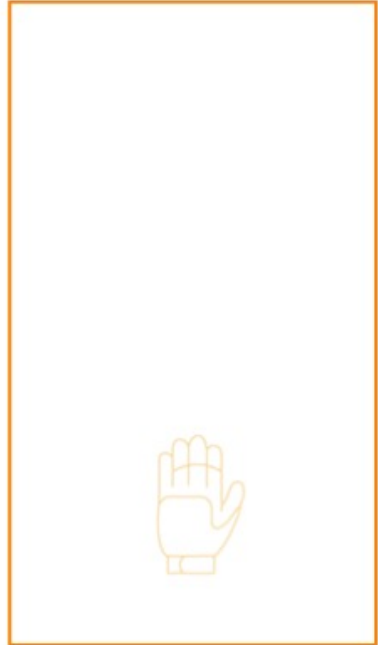
Transport

Conditions, vehicle, road, batch
size, duration, vegetable container



Unloading

Conditions, vegetable
container, handling



3.3 Consumer test

The important factors when buying vegetables in Ghana ranked from important to less important are: weight, health benefit, safety, affordability, bargain, shelf life, appearance, taste, bulkiness, naturalness, price (cheap), origin and value for money (Antwi & Matsui, 2018). Overall people want to buy good quality vegetables that are healthy in terms of pesticide use and nutrients (Baffour, 2024; appendix 1.5). Quality is assessed by weight/size, appearance (signs of damage) and shelf life. Healthy is considered for nutritional benefits, safety in terms of contamination and traceability. The price willing to spend depends on the produce. These three most important factors are taken to perform a test with consumers to see what packaging they would choose influenced by quality, health and price. To get to know what produce people want to buy, how much they are willing to pay and what packaging would be preferred.

Choosing between options

Ask them to rank what they look at and what is most important when buying vegetables.

Current packaging (with appearance) and price → What do you go for in the current market, what is perceived as higher quality or healthier

- €€€€ Packaged
- €€€ Unpackaged no bruise
- €€ Unpackaged in little bruise
- € Unpackaged bigger bruise

Different types of packaging with good-quality veg → What packaging indicates the highest quality and what do you want to pay the most for, what is perceived as most healthy?

Unpackaged tomato

- Tomatoes in an unperforated bag, condensation
- Tomatoes in a perforated bag, no condensation
- Tomatoes in foam tray and film
- Tomatoes in cardboard
- Tomatoes in banana leaf

Supermarket, farm and no package marketing and traceability → Is it important to know where it comes from & what is perceived as healthier and higher quality

- Tomato in plastic bag
- Tomato in a plastic bag with supermarket sticker
- Tomato in a plastic bag with fresh from farms sticker and phone number

Photo's

€€€€ Packaged in supermarket



€€€ Unpackaged no bruise



€€ Unpackaged little bruise



€ Unpackaged bigger bruise



Unpackaged tomato condensation



Tomatoes in unperforated bag,



Tomatoes in a perforated bag, no condensation



Tomatoes in foam tray and film



Tomatoes in cardboard



Tomatoes in banana leaf



Tomato in plastic bag



Tomato, plastic bag with supermarket sticker



Tomato, plastic bag with company sticker



Appendix 4

Farmer interviews & observations

4.1 Farmers meetings

16-04-2024

Farmer 1, male, farms on university land

Meeting transcript

A: I was wondering if you can maybe describe your farm, so what do you farm and how big is it?

F1: I work at the campus, I use the school land.

A: Do you farm vegetables, fruits or everything?

F1: Vegetables, cabbage, salad, meat, cucumber, watermelon.

A: That is because they grow well here

F1: Yes, they grow well.

A: So if you grow the crops and then you are going to sell them, what does that look like?

F1: They come, okay. The market woman they harvest and pack it.

A: And then they pack it themselves in bags?

F1: Bagged.

A: And then they take it to the market and then they pay you first?

F1: No, they sell before coming here.

A: Okay, they sell and then they pay you.

F1: Okay. So if you have good quality vegetables and sometimes not. Okay, and then you get less money.

A: How much less do you think? Like if you sell a good quality vegetable, how much do you get?

F1: 1000 Ghana per bag. I have 50 bags.

A: And the 1000 is for good vegetables? And if they are not good, how much do you get for one bag?

F1: Less, almost 500.

A: So if you harvest them and sell them, do the vegetables get damaged?

F1: No, the transport is the cost of the market women.

A: Yeah, okay, so you don't know. So you yourself, you don't have to bag it?

F1: No. Yeah, okay, they put it in bags and they take the bags as well.

A: And is it bags or is it also crates for the tomatoes?

F1: For the tomatoes is in the box.

A: What do you have in the bag?

F1: The cabbage and the lettuce is in bags.

A: And if you buy it in the market, there's no packaging, right?

F1: No, it's just on a... It's empty.

A: And you only sell to the market?

F1: I'm working. Always, yeah. They came to my farm.

A: And they just sometimes come by or you make arrangements with them to come by every week, right?

F1: Every week.

A: Thank you very much.

16-04-2024

Farmer 2, male, about 2 acres of own farm land

Meeting transcript

A: Nice to meet you.

F2: Nice to meet you.

A: You also have a farm here? And what do you grow?

F2: Tomatoes. Cabbage. And pepper.

A: And the pepper, is it like the hot pepper?

F2: Hot pepper.

A: And how big is your farm?

F2: Like, the tomatoes is one acre. And the cabbage is half acre.

A: Okay, and you also, you sell to the markets as well?

F2: Yeah, market. So is it the same with him, they come by, market women come, and then they harvest.

A: Yeah, every week?

F2: Yeah, the tomatoes twice a week.

A: So what price do you get?

F2: It depends on the time of the year.

A: Okay. And for the cabbage and the hot pepper, how much do you get?

F2: The price may be different depending on the time of the year. For the cabbage maybe 800 per bag

A: And how big is the bag, do you think?

F2: Size of the sack. (about 1 metre high from the ground)

A: And for the hot pepper, how much do you get from the pepper?

F2: Sometimes 500 cedi is for the bag. It's for the big bags.

A: They all put it in the same bags? It's like fiber bags?

F2: Yeah, fiber bags.

A: And do you also, so if your produce looks better, it's better quality, then you get more for it?

F2: Yes.

A: And does that depend on the harvest, or for how much time it's on the farm, or what does it depend on, that you get more or less money for the whole thing?

F2: Depend on the season. The price depends on the season.

A: And do all the vegetables depend on the season, if you, how much money you get for it? Or is it? Or is it also if the tomato, for example, is damaged, do you get less money?

F2: Sometimes you get more or less. It depends.

A: Yes, so also you don't have to package for the market.

F2: Yes.

A: Do you know if any farmers do the packaging themselves, or...

F2: No. It's all the market women.

A: And then the market women, they take it to the market and they also sell it?

F2: Yes.

A: And if they, like, if they sell it all, you get all the money, and if they sell not everything, do you get less money, or do you still get all the money?

F2: It's about the market or the season.

A: Thank you

16-04-2024

Farmer 3 female, ¼ acre of own farm land, interview done with translator

Meeting transcript

A: So I was first wondering what kind of farm do you have, so how big or how many people and what she grows.

F3: So she does pepper, beans, garden eggs.

A: Garden eggs?

F3: That's eggplants, yes.

A: Ah it's eggplants. The crop she grows, is it because it grows well? Or because there's demand?

F3: What she says is that, for the selling of the crops, she's a marketer herself. She does market it. She cultivates the crops, and at the same time, she markets it herself. She herself is a marketer. And again, there's demand for it. That's why she does it. And again, she's saying that she selected those crops because the soil over there, they are very, very good. So this is her. She does market it.

A: So she grows it, and then she markets it. She takes it to the markets herself as well?

F3: Yes.

A; In the car, or how is it that she takes it to market?

F3: A taxi to transport it to the market.

A: And how does she take it like in bags or in crates, sir?

F3: So she said for the eggplants in baskets, pepper in baskets. Okay, so for the beans, it's in sack.

A: And the baskets, or it's like plastic baskets or metal or what kind of...

F3: Okay, cane. Cane baskets.

A: And how big are they?

F3: Okay, for the sack, it's quite large. It's the big ones (1 metre from the ground). The basket is medium-sized (about 50cm diameter).

A: So maybe before taking it to the market, is there anything, just like cleaning or sorting or anything like that?

F3: So she said she does the sorting. So she makes a selection. So she puts the bigger ones. She separates it medium-sized, then the smaller ones. So he does the sorting according to size. And then also for the eggplant, it does according to the ripeness. Some are white, some are reddish, yellowish. So she sorts them according to colour too. How ripe is it.

A: And does the price differ for the sizes and the colours?

F3: So he said, both tones and the prices, I can say, the prices are both medium and different. And the price is different. So with the sizes, they are all different. So the bigger ones will have its own price. Medium-sized will have its own price. And then the colour too,

the colour too differs. The white one has a higher price. Then those which are more ripe, some are yellow more yellow, those are different, the price is lower. So, white is less ripe. And that one has a higher price. But the yellow is more ripe.

A: Do all the vegetables reach the market or are they sometimes damaged or that they, their quality get less because of transport or anything?

F3: So when the vegetables gets to the market, they show little bruises. It's not the same as when it's harvested on the farm. So when it gets to the market, they see little bruises.

Depending on the type of vegetables, for garden eggs, tomatoes and pepper too,

A: And then you get less money for that produce?

F3: So it's confirming that when they see those bruises, they buy them at a lower price. But those fruits have maintained its quality and everything. They buy at a higher price. So in that case, there's a loss along the line somewhere.

A: So how does the selling go?

F3: She does prepare it before it takes it to the market. So the day she will harvest, she will do all the sorting, all the cleaning and everything before. And then she will take it to the customer that is already at the market.

A: So she has people ask for the vegetables and then she goes to the market?

F3: So she has customers at the market. So it's not that she takes it to the market and she is looking for buyers. But rather she has her customer base and when it takes it to the market, she just supplies it to them.

A: So the customers they contact her on what they want and then she harvests that and takes it to the market?

F3: So she says it's a two-way affair. If the customer wants something, they will place a call and sometimes in about two weeks when it's ready, like when everything has arrived, they can also call the customer to find out if they need to. So it's a two-way thing.

A: Like how does she decide on the price with people? Is it like a fixed price or how much is it?

F3: So you see that a lot of factors determines the price. And the number one is the season. In Ghana, you have two major seasons, the dry season and the wet season. Usually the wet season, people produce a lot of the vegetables. So it's in abundance, so you have to do more. So those seasons, usually the prices are low. But the dry season, where you don't have a lot of rainfall and people have to struggle a lot to get to rain, those ones, they sell them at very high prices. So the prices are determined by the seasons. So that's number one. And number two, is the demand. So the price depends on the demand, the season,

A: Yes. So I think she only sells on the market, right?

F3: Yes.

A: When they sell it, almost no packaging, right?

F3: They do a little bit of packaging before. Sometimes poly bags, sometimes some of them have deeper bags. Yeah, they are all poly bags, quite the same one. So if you want to buy in small quantities. Yeah, those one will put it inside for you.

A: Well, maybe last because she sells directly to customers. Is there some kind of marketing or... That people know, for example, that she sells to products and that the products come directly from her. So there's some promoting of her produce or marketing.

F3: They say she does not do any promotion as a customer.

A: Thank you very much.

Conclusions farmers meeting 1

- Vegetable crops grown in the Kumasi region by local farmers include cabbage, lettuce, tomato, cucumber, pepper, and eggplant.
- Many farmers use a road to market where they cultivate crops, market women come to their farm, harvest the produce and put it in big sacks or crates. The women transport it to the market, sell it and then afterwards pay the farmers. In this case of road to market, farmers could benefit from investing in packaging since they will receive more money for better looking vegetables, although they feel packaging is out of their scope of work.
- Good quality products without bruises and damage earn you more money, maybe even double the price of damaged products.
- The price the farmers get for the produce highly depends on the season. In the wet season prices are low because growing is easy and abundant, in the dry season growing is hard to prices are high.
- One of the farmers does farming but also takes on the role of the market woman. So she knows what the demand is and grows that. She has a customer base she knows at the market so sometimes they call her or she calls if they need anything. That is how she sells. Then she harvests, cleans and sorts the products according to ripeness and size. The less ripe and bigger vegetables sell for higher prices. She transports the vegetables to market in sugar cane baskets of 50 cm in diameter in a taxi.
- Almost no packaging is done at the local market. Vegetables are sold in big sacks or if they are sold in small quantities small plastic bags are sometimes used.

17-04-2024

Farmer 4, male, 2 acre commercial farm and some for home use

Meeting summary

The farmer has 10 years of farming experience and currently cultivates 1 acre of okra and 1 acre of maize/corn for selling. Next to this, he grows plantain, banana, a bit of pepper, eggplant and cassava for home use. The reason he grows these crops is the demand for them. He sells the majority of it and uses some for his family. When he can grow and when he plants the crops depends on the season, he has to depend on the rain because he has no irrigation.

He sells the vegetables through his wife who is a market woman. He harvests the crops himself and gives it to his wife to sell. His wife sells it to their client base and at the market. Maize is often sold in small portions in plastic bags at the farm. The customers come to the farm to pick it up. The okra is mainly sold at the market and what isn't sold is sold in small portions at the farm/at home. The okra is transported to the market in cane baskets or plastic bowls. If the products look better and are of better quality they get more money for it. Therefore he says it is very important to keep the ants away from eating the leaves because the leaves of the plant help the plant live which produces better okra.

The price depends on the season. In the dry season, you get more money than in the wet season. It really depends on the demand and the availability at the market. Okra spoils very fast, it has to be consumed in 1 to 2 days so you can't package it. The maize is packaged in big bags.

17-04-2024

Farmer 5, male, about 1 acre of farmland

Meeting summary

The farmer grows a very wide variety of vegetables like cauliflower, cabbage, squash, carrots, cucumber, chillies, radish, spinach, coriander, parsley and more. He grows these crops because of the demand and he sells them through the local market but also to his customer base who comes to the farm. He says that if you are a smart farmer, like he is, you know the prices at the market so you know what your produce is worth and what you can sell it for. For a higher quality, good-looking vegetable you get more and for a bigger size you also get more. He also sorts the vegetables according to size at the farm since that way he can get more money for it.

He does the transport to the market himself on a tricycle. He loads the produce in big sacks. For some vegetables, the sacks are cut open and then the produce is put on it and the corners are tied together again. This is done for cauliflower and radish. Sometimes when the vegetables have to go on transport to customers further away they are put in a wooden crate on a truck to another city. There the customer collects it from the truck and pays. On the truck, the vegetables might get damaged because they are put on the bottom and the skin is damaged by the wood.

For packaging, he first takes off the bad leaves and then for radishes, he bundles them together with leaves from a palm. Chillies are put in big bags or sacks. When sold they are measured in a certain container and if you want more the amount you want is measured by the amount of containers that go into the bag.

For good quality vegetables, you get more money. So for 6 radish pieces of good quality, you maybe get 10 cedi, for second-grade quality 7 cedi and for third-grade quality 4 cedi. He also says all good quality vegetables are sold first so if you have bad quality it gets sold last or not at all. Since he has good quality he has a customer base and does some promotion. He has a logo and a colour of his farm. So the produce is sold in buckets of his color. He says that is why he never has a problem selling his food.

17-04-2024

Farmer 6, male, about 4 acres of farm land

Meeting summary

The farmer grows beans, akatua (some sort of bean), chillies, groundnuts and onions. He has 1 acre of onions, ½ an acre of chillies and 2 acres of akatua. He grows this because of three things. First because of his livelihood, he likes it and gets money for it, secondly because of demand and thirdly because the soil/area is good for these crops.

He sells the onions directly from the farm to market women. He harvests the produce himself and put it in big bags of different sizes. The onions go in big bags with an open structure, a bit like a net. And then he sews them closed with a needle. The chillies and the akatua are handled similarly. He harvests them, brings them to the farm, sorts them and dries them in the sun, then he puts them in different-sized plastic bags. The big bags, about 1 meter high from the ground cost him 7 cedi and an even bigger bag costs 10 cedi. After putting everything in bags he puts a price on it at the farm and then sells it to market women. He does this because it is his style and he says that it ensures he gets a good price for his produce. Sometimes the market women cheat on the price so this way he gets more money, he can only do this because other farmers sell different things and he is one of the few selling dried chillies. He gets a higher price for good quality produce so he sorts the produce by picking out the ones with cuts and bruises. The damaged produce gets sold for a cheap price to the street food makers and the quality produce goes to the market for a better price.

Conclusions farmers meeting 2

- Most farmers grow the crops they grow because there is a demand for them, additionally appropriate soil and climate for the crops are important.
- Sorting the vegetables will increase revenue for farmers. By selling good quality, big vegetables you sell more for more money. The damaged vegetables are also sold for less money or to street food makers. They sell for about half the price.
- When produce is not easily damaged by pressure it is put in big bags or sacks, when the vegetable is more fragile or prone to squishing it gets transported in cane baskets or plastic buckets.
- When produce is sold at the farm itself to consumers or when there is a very close link to the market women the produce can also be harvested by the farmer himself.

4.2 Farm visit during harvesting

17-04-2024

Farmer 7, female, completed the ACHI programme, 14 years of farming experience

Observation & interview summary

We arrive at the farm after walking through the field of other people, they are all next to each other. On her own piece of land she mainly farms lettuce and spring onions because they grow easily and fast there and the spring onions are low maintenance. By growing these crops she can get the most money for her effort. Sometimes she also farms cucumbers because they are in demand and you can get a higher price for them, but the time is not right at the moment, so currently she only grows spring onions and lettuce.



We walk to a different part of the field to see the harvesting of the lettuce. How this goes is that the market women come to the farm, they choose the beds they want to harvest and agree on a price with the farmer. Then the market women harvest the lettuce. They pull the crops out of the ground, remove the ugly outer leaves and place the heads of lettuce on a cut-open fibre sack. They kind of build a tower, sprinkle some water on the lettuce to maintain the quality better and then they tie it by the corners of the cut open fibre bag. Sometimes if a customer buys it directly from the farm they already put it in a plastic bag. They then transport the lettuce bags of the farm by carrying it on their head.





Then the market women take the lettuce to the local station and mark it with their own mark. The next morning all the produce at the station gets loaded on a big truck and taken to the market. There the market women collect the produce that has their mark on it and sell it at the market. Lettuce needs to be sold within two days after harvest or they go bad. The lettuce can sometimes be flattened by the transport. Therefore the market women place the lettuce in water at the market to let it gain back its shape. After they have sold the produce at the market they pay the farmer the money next time they come to the farm.



For the spring onion, it is the same. The difference is that sometimes the market women already put it in smaller portions in little plastic bags and then place it in the cut-open fibre sack. The little plastic bags with spring onion are 5 cedi. At the end of the walk, The ACHI manager Ghana wants to buy two beds of spring onions for the college. At first, he agrees on the price per bed with the farmer, which is about 150 cedi, a bed is about 1 meter by 4-5 meters. We pull the onions out of the ground ourselves together with the farmer and two little kids that happen to be around. Then it gets packed and tied up in the cut-open fibre bag and a man takes it to the car on his head.





Conclusions observation at farm

- Getting as much money for the least amount of effort is a driver for farmers.
- Good quality and appearance of vegetables is important for sales, damaged or ugly leaves are removed and water is used to maintain freshness.
- Anything that is packaged for consumers directly is put in plastic bags.
- The way of transporting lettuce and spring onion by tying them in cut-open bags is a pretty efficient way of working. It works well on the farm and for these products, the transport also does not affect it very much.

4.3 Visit Farmer supplying supermarket

25-04-2024

Owner of Fresh from farms, also farms on small scale herself

With her company fresh farms she sources high-quality vegetables from several farmers with or without greenhouses and also from herself. Then she washes, sorts and packages them and sells them to Melcom supermarket in Kumasi.

Interview transcript

S: We don't have a cold chamber in place. So technically what we do is that we got an AC to keep the vegetables clean. Because if you bring them in and they're not ready to be packaged because of the heat, it loses its quality. So we try to put the AC in here. So what we bring in there is we put them here as a cold chamber. And then we package and then we do sorting and grading. Some of them, not everything you can take to the market. So there are some that are obviously not in the shape. So we take those ones out and pick out the best.

A: And what do you do with the ones that are not good for the market?

S: For the house. We feed them that's my case.

A: Is that a lot?

S: No, no. So because of that when we are buying, we make sure we have the best. You can't just go there and pick anything. So you look out for the good ones. But definitely you get about 10% that's maybe 5, 10 to 5.

A: And you go there and then you harvest yourself or they harvest and you pick them out?

S: Sometimes. Sometimes I harvest it. Sometimes they're already done. You know I just pay for it. I pay for it and I bring it in. That's what I do.

A: And plastic crates they're from yourself?

S: Yes, I bought them.

A: Because they are also better for the quality, right?

S: Yes, because of the air spaces. So when we are done packaging, we put them in. This is our price list here. After that we just put them on our invoices and then the driver. That is our car outside. So these are my labels. I think I saw this on the flyer for the ACHI. I called Mr. Darbah and I was like, who puts my... Who did that? And he had no idea. So yes, so we are in the late season. So now it's very difficult to get vegetables. It's not going to rain. Most farmers in Ghana are dependent on rain for the land. It depends on the rain. Just a few of them are lately using their growth system. They don't have any irrigation. Sometimes it's difficult. You call them... Some of them are not available. So for supermarkets, we

understand. So we buy whatever they have, we buy the good quality assets. To let us, we wash them. We wash them, sort them out, package them. You didn't come at the right time. We used to have a lot. You come in the whole place is full. But now it's very difficult.

A: So, you are now planting?

S: Yes, because the rain is going to flow. Yes, and even this year, the rain has delayed. We are almost in the rain season and we have few rainfalls. It's not good. But we pray that maybe we will let our thoughts be here.

A: Is the rain also shorter periods in our time or just late?

S: So it's supposed to start in march. And then around the time, we should have less and lots of droughts. It's not just for the case. And even when it rains, it doesn't rain that much. And the sun too is very strong these days. So the few rains that came down, dry up by the sun. So that's the challenge we are having now. I have a farm. And over the years, I've done habaneros on the air. That's even not possible, you know. But I love to have my farm. So I try to... My concept is to give people things that are freshly from the farm.

A: Yes.

S: Like it's everything from the farm. I sell out veggies, meat, fish. Right from the farm, from the farm's source. You know what you're eating. So that's what I'm saying. That's just the concept I have. So even in this period, the vegetables are not really available. I do more of the chicken. So I have small shops around where I sell the meat.

A: So you sell to the supermarkets and then to the small stores.

S: No, the supermarkets sell the vegetable, the meat, I sell them myself. I have my own shop, meat outlets. And then sometimes if it's from the market and you request, I'll bring some to you. But I don't do that often, mostly to the supermarket. I'm still doing the market. I'm going to do the market to do the chicken and the fish. But the veggies, they are from the supermarkets.

A: So is it one specific supermarket chain?

S: Yes, from now. It's just Melcom. Have you been there already?

A: I've not been to Melcom. I've been to Shoprite. But they only do packaging themselves, I think. I saw all the vegetables from here, they packaged themselves. And then there were some vegetables maybe that were imported. They were not packaged by the supermarket.

S: Melcom too, they also have imported vegetables. So I do the local. And I'm just in Kumasi. Melcom has a lot of branches. Initially they wanted me to take over the other branches. But I guess, yeah, times and conditions were not favorable in his business. So you need to be careful what you take on.

A: Yes, because otherwise you have to transport it somewhere else.

S: So I told them I am busy. No, please, no joke. I'm already a busy person. I didn't want to burden myself that much. So I told them I'll take care of the Kumasi branches.

A: And you see it's also that Melcom, they ask you to package it. Or is it just better for you to package it because you can get more money or extend shelf-life.

S: Yes, they asked me to package and put my own label on it. So I'm just like a third party seller to their shop. So even though they are selling, when I send it there, they add their own at the cost. So if I give it to them for, let's say, 10 cedi, they'll add more. So this is my price. But this is not what is sold in there. They add their own here because they also want profit.

A: Is it a lot?

S: Not much. Sometimes I've heard incidents where I need to complain because the point is, there's a part of the deal that says, if you're having too much damages, if I send the goods and shelf life is spoiled and all, that means I have to replace. So if you're also making the price too much, the people are not going to buy this, it's going to get damaged and I have to go and replace. There are instances where I have to confront melcom, they know I'm not accepting the price. I'm looking at what I'm giving. This is way too much.

A: So you sometimes go check it?

S: Yes, I check it. Yes, I go there. And then I go there. So I talk to them and they have a long protocol because you go to the shop, the manager is there, he can't do anything about it unless he communicates to accra. That's a challenge, yes. It's quite cumbersome sometimes. So you need to talk to them from a crowd, chase them, what's up, before you go, what you want them to do for you. Paymentary is not upfront. When I send it, I add my invoice, they'll give me a computer generated invoice from their system and I have to wait for seven days. They say something like this but it's not true. So normally, because I don't want the money to be in bits and pieces, I just know, and maybe after a pile of invoices, I scan all of them and then send it to them and then they pay through my invoice.

A: So you kind of agree on the price when you give it to them?

S: They agree, the price, before I put this, they have to agree with me. It's just like this is what it goes, you take it or not. So we negotiate and then they are like, no, this one I'm not paying this much and then we come to an agreement. We inform them, so on their system these are fixed prices. So even if our price is to change here, it's a long procedure. Yeah, I can't change it unless I negotiate with them again.

A: Because I heard also that it's like, because of the different growing seasons, that in the wet season vegetables are usually cheaper and in the dry season they are more expensive. Do you change your prices to that as well?

S: So all we do is leave it on that balance. So when the season is in and you have it in abundance, it's an advantage for you. And when the season is on the low side, you have to balance it and so they understand that. Because it's in wet they themselves know that the things are scarce. They are in Ghana so they know. They get to know that this item is scarce on the market. So even if I am bringing them, these are going to be a lot to get those items for them. So they are kind of relaxing in terms of the scale. So that's how you approach it. It's not too easy, but... So it's like you have to invest before you get your money. It's not like I bought them sooner, because it's going to give me my money. Yeah, you need some room to invest.

A: And with the farmers you buy them from? Are the prices then their different throughout the year? Or are you paying them a fixed price as well?

S: No, there's no fixed price. The farmer will tell you how much he wants to sell it for. And even those in the greenhouses, occasionally they bring price updates of increase, maintenance, all that. You still can't go to communicate with the supermarket people who will not agree. So what I do is, okay, so if I'm scaling 500 grams for maybe 10 cedi, and I have to reduce it. That's how I'm able to also get my profits. I use a quantity of how many are fits in the package. So if they react to it, then I have to. Because if you want to compromise, oh, now greenhouses are saying a kilo of my dash is this. They will not agree. The process is too long. So if they think that the quantities are not enough, they rather come to me, then I will take them to home. So I don't bother, because they will not agree. For price change to happen, I think, I've done that once, since I started working with them more than a year now. I've done price change once. So even though I refused to sell to them, and they were calling me calling, I said, oh, we need to increase the price. That's why I'm not coming, because the things have become expensive, and I need to, and even though I only added just two cedi, I don't know whether you know. It's small. Just have the small, very much small. But it was okay, because at least that would take care of the packaging costs. Because we use plastics and all those things.

A: Where do you get all the, you order all the packaging or do you just throw them down?

S: We have shops in Ghana that sells those things. So we just go there, look at the one that is small, and we don't just do it.

A: And are the packaging, like the plastic, is it expensive or is it okay?

S: Yeah, it's okay. After every packaging, we do the assessment. We check how much goods we purchased, how much plastics we have used, and we check our profit margin. So I wouldn't say it's bad, at least after paying for all of this, they used to make something out of it. Yeah, yeah, it's like a small, like for some of the products, it's like a very small price. So like, no, we do the general evaluation. So let's say this week, I've spent like 2000. Packaging, the produce, the transportation, everything. So after I'm done with the package, and I write the invoice, how much was the invoice? Okay, so if I got invoice of 2500, it means that the 500 is my profit. So that's how it is, to see whether you're losing or not. But there are some days

that obviously you are losing. So that's like I said. It's not all the time. So you have to manage business like that. If sometimes, even... I'm not, I've not had any day that I've lost, but at least sometimes I've played even. Sometimes it's hard times. I've grown in business to appreciate that you... It's not about really, really, really, really, really, really, really. You're not really everyday, and you're not going to make maximum profit in one transaction. No, it takes time. So I have that passion that I'm willing to use for it.

A: Yeah, but it's also nice because like compared to maybe other farmers I spoke to, you have like good equipment as well.

S: So this is like for keeping the vegetables good. The fruits are very nice. Other people don't have that. It's also you can give them like the nice vegetables.

A: So if you go like harvest or pick stuff up at the farm, you just go with the car or is it...

S: Yeah, we go with the van. Sometimes, yes, you go to put the van. That's another time to... farmers will bring you to a farm and you take it. You take it just yourself.

A: And then when it goes to supermarket, you also take it to supermarket yourself?

S: Yes, yes. With the van.

A: Because that's also, I think, why you can have the plastic crates.

S: Yes, so you put them in the plastic. We just send it straight away, they put it in the cars. Yes, the sooner it's there, the better it is. Yes, because once it goes into the plastic, that's why he's kind of cutting the ends of the plastic to allow some air. So it gets to the vegetables and then you cut the tips to allow some air to come out. The heat is too much. Yes, otherwise you get water inside. So we try to get the water out. Yes, because that's what we do.

A: And do you always have the same size bags or do you just sometimes buy different bags?

S: The packaging materials, they are a lot. So when you go to the market, the ones that are available, it's huge. Yes, it's just whatever is available. And not whatever is available. There are some that are not good at all. And for instance, we have one that when you go to the shop, a little handling and then the plastic is coming off it. So we avoid those ones. You need like a sturdy one.

A: And then when you take it to the supermarket, they take it out of the crate or you just put it back in the bag like that?

S: They will come out from the shop, I will count for them. Then they take it to the inside and put it in the chamber. We don't use this sealant machine. We don't use it because, for instance, from their head, sometimes they tell, oh, the tomatoes will be there and we bring it. Not everything is damaged, but you see one of them soft. So they just untie it and pick

the softer one out so that it doesn't stain the rest for them to spot. You have about five pieces of tomatoes and just one of them is going bad for some reason. It's soft, so they just untie this. So if you seal it and tie it, it will be difficult for them. They want to be sure that the vegetables are in good condition all the time. So that is why we use this to close it up. So that you can easily be opened by the attendants, not the customers.

A: How do you decide from which farmers or greenhouses you buy the produce?

S: No, I have over the years established a few farmers who I know do not use too much of pesticide and insecticide. Yeah, my target markets. I tell them this is where I'm sending my stuff. These are the couple people I'm selling to. I don't want these kind of vegetables which are bad. So over the years I've been buying from them and it's good. And there are others who also like... So when I had complaints of less shelf life, I just knew that the farmer is not doing it. And now they just take you off.

A: Also, for example, they connect to the college or to Holland Green Tech?

S: Some of them are connected to Holland Green Tech. Some of them plant seeds from Holland Green Tech. Even Holland Green Tech would call me that, oh, there's a farmer who has this and that, can you buy it? Yeah, sometimes I get those connections from Justice.

A: That's nice for you, right?

S: Yeah, you know Justice? Justice. He used to work in Kumasi, but now he's in Accra. So he normally calls me, and says, Madam Susan, we have this farmer here, he says he has this and that, can you buy it? He linked me up sometimes. I started this work as a result of my connection with Holland Green Tech. After doing the programme at the college. So we have a lot of Green Tech, so I decided to take advantage of this. Let me see if I can go to my website.

A: Ah, nice, you have a website. Is that also how you get new customers?

S: Maybe, because I think mail call is because of my website. That's my link up with me.

A: And was it also before you did the program, you also did this or you only did the first?

S: I did the program right after school, I did the farming. But I think the program also did a lot of exposure. I did the years for the farms, I did the 20 years. So I think the program exposed me to Holland Greentech. I became friends with them and I decided to try some of their seeds on the farm. So just to sort of nudge them for me, I would go and get them to the farm to plant. So we decided to have this program to come to the farm to see what I'm planting. So we build our relationships. So when the course was launched, they asked me to take part. So I came around a couple of times. And even last year, the last couple before this one. I think I had a person to go and lecture for me. Ah, the school.

A: Yes, so maybe... Because you say you try to keep... Let's store the vegetables here for at least some time. How long are they usually there, you think?

S: So like this one came in yesterday. So they come in a day before the packaging. Yeah, in the evening maybe. Sometimes in the morning. Because as soon as it comes in, they put the cooler on. Yes, so it becomes cool. The next morning, we start packing and at 12 we bring the groceries. So it's maybe a day.

A: So maybe when you buy from the farmers, like the price differs sometimes. Does it depend on the season or also on how the season looks?

S: It depends on the season, how good they look and sometimes they have the demand in the market. Sometimes it's season, sometimes because of high demand. But it also changes because everybody wants to pay more. Sometimes the demand is one of the fastest things. Those farmers who are used to make themselves to slightly organize, I don't think it's the end of the world. And we know them. Yeah, they can also take it to the market. Because it's more healthy. And that is what we want to sell to the supermarket because of the class and everything, the shelf life issues. So if you go and the demand is high, but whatever price it gives you, you still make a margin out of it. Because once you pack it, the value is raised.

A: And do you know also because you do it in a way that you buy from the farmers and sell it to the supermarket, are there also farmers that maybe make a profit by selling directly to the supermarket?

S: If you go to Melcom right now and you want to sell it, they will refer you to me. They say sell it to her. That has been happening. So farmers will go there and they connect them to you. Yeah, and it's maybe also that if the farmers sell their produce to the supermarket, they need to meet the demands, they need to meet the demand. And you know, they don't want to go through the stress of packaging and cleaning and sorting and grading and all that. Sometimes they bring some stuff from a truck with their name on it, especially the major seasons. You go there, they've also brought some. But you know, it's business, so you can't complain.

A: I don't know if you have it anywhere, but how much the packaging cost.

S: Okay. So on average, this whole pack is like, it's 100 pieces. So one is like, 30 pesewa. And then the whole pack is like, 30 cedi.

A: Because I was wondering, when you like harvest the vegetables yourself, I think you just put it in these crates and then take it there.

S: Yes, and there are some after-washes. You see, she's washing carrots. Carrots, the roots is, because it's a roots vegetable. Yeah, it's dirt. It's always this. In the open market, they will sell it for you, you come and wash it. Yeah, it's not all of them that you can wash. This one, if you wash it, it will go bad. So we kind of clean it up a bit.

A: If you pick the vegetables up from the farm and they are harvested already, then you have to, then they have it somewhere and you need to put it in your crates.

S: Yeah, so I always go with my crates. Yeah, because otherwise you have to put it again. They put it in baskets maybe? Yeah, so it sucks mostly. You can do this best for the quality.

A: Okay. I think that were my questions.

S: Thank you, thank you, thank you.

A: Thank you very much.

Photo's



EDFERS GREEN COMPANY LTD			
PRICE LIST			
CODE	ITEM	QUANTITY	UNIT PRICE
139191	White-organic Cucumbers	500g	13.00
139990	Carrot/flower	1 medium piece	12.00
133416	Spring Onions	1pack	5.00
139394	Lettuce	1pack	5.00
136631	Tomatoes	500g	20.00
139397	Habanero Pepper	250g	10.00
141259	White Radish	500g	10.00
139989	Cucumber Kg	1kg	14.00
139705	Salad Onions	500g	22.00
139984	Mont	1pack	5.00
143191	Lemon	1kg	10.00
139706	Carrot	500g	12.00
136600	Cherry Tomatoes	250g	25.00
139597	Bell Pepper	500g	12.00
139983	Beetroot	1pack	12.00
139985	Peppermint	1pack	4.00
139986	Ginger	350g	7.00
139987	Garlic	200g	12.00
139988	Tumeric	500g	10.00
139993	Cabbage	1piece	12.00
136290	Celery	1pack	5.00
136290	Parsley	1pack	5.00
141260	Chilli Pepper	500g	12.00
141262	Aubergine	1 big piece	6.00
140011	Shallot	250g	12.00
143189	Squash	1 big piece	12.00
143190	Spinach	1pack	5.00
143192	Lime	300g	10.00
143193	Basil	1pack	5.00
	pls can I get code for the following items		
	Garden eggs	500g	8
	coriander	1pack	2
	casoyam leaves	250g	10
	okra	500g	10
	grape fruits	1kg	10
	butternut squash	250g	8
	red bell pepper	500g	60
	yellow bell peppers	500g	60

Conclusions farm visit

- When selling vegetables to the supermarket they only accept high-quality vegetables without bruises or damage.
- Melcom supermarket asks the supplier to package the produce.
- Reasons for packaging are because it adds value, the supermarket asks for it and you can establish a brand.
- When you are in charge of transporting and storing vegetables is pays out to invest in plastic crates, because you own them and they don't get lost or stolen.
- The supermarket pays a fixed price per vegetable throughout the year, the supplier has to balance the varying price over the year because of season and demand themselves. It is very hard to raise the agreed price with the supermarket.
- Of what is harvested for the supermarket about 10% doesn't make it there because of damage and gets consumed at home.
- Yield of the majority of farmers depends on the rainfall.
- Plastic bags cost very little compared to the produce. To prevent condensation inside and rotting/spoilage a corner is cut off to let air in. It is tied with a string so it can easily be opened in case decayed products need to be taken out. There are low and high quality plastic bags, the thicker ones do not break the thinner ones do sometimes.
- The price can be higher for high-quality, healthier vegetables. This means when less pesticide and insecticide is used, you usually notice whether that is true when looking at the shelf life.
- Th ACHI programme connects farmers to Holland Greentech which allows for a large network and better business.
- Most 'regular' farmers do not want to go through the stress of cleaning sorting and packaging.

4.4 Interview Farmer Volta region

29-04-2024

Farmer mainly producing chilli pepper with occasionally other vegetables

Interview summary

She is a farmer in the Volta region of Ghana. She grows chilli pepper as her main product. This is because it grows well in the region as well as in her soil. She says she has a very good type of chilli pepper that can withstand a lot of diseases and just in general does very well. Next to this she occasionally grows vegetables like tomatoes, eggplants and spinach when the demand for it is there. She sells the chilli pepper in fresh form, dried form and also processes it into chilli powder. The fresh pepper is harvested and then put in plastic crates or cane baskets. This is done to allow for ventilation when storing and transporting the fresh peppers. She says the fresh chilli pepper will decay because of the heat if you put it in big bags. When she sells the pepper it is transferred to the container of the buyer and she takes the crates or baskets back with her. Occasionally she also leaves it at the client and picks it up later. The dried chilli peppers are put in bags because they have a long shelf life and will not decay from the heat like the fresh ones. They are put in plastic bags to sell to consumers. The chillies that are processed into powder are put into container she buys.

She sells mostly to her customer base and once to the supermarket. Her clients call her if they have an order and then she will harvest and prepare it for them. Sometimes she is left with a surplus because clients cancel their order or decide to take less in the end. When this happens she can dry the surplus or process it into powder, minimizing the losses after harvest. When growing vegetables there will always be some crops of which the quality is affected, so you will always have some vegetables that are looking less nice. She makes sure to sell the high-quality ones in fresh forms to clients and uses the less nice looking ones for drying or processing.

She aligns her price with that of her competitors or the market. She does this by making a competitive analysis to see what the prices are and then bases her price on that to make profit. She sells the fresh vegetables unpackaged because it is an extra cost as well as effort which means you have less time for other things. The combination of price and effort does not result in profit in the end. The one time she sold her produce to the supermarket they packaged it in their brand for her which she thought was fine because it saved her money and time by not having to do it herself. Apart from that she says packaging is more used for export products as well. She mostly sees foam trays with plastic film. Also she says paper bags or other paper products do not work because they break easily when they come into contact with moisture. Lastly, she said she definitely would be open to trying packaging if it could pose a benefit for shelf life or maintaining quality, depending on the cost and effort.

Conclusions interview

- Some farmers are aware that fresh peppers, but also other vegetables decay less fast in crates or containers that allow for ventilation instead of using bags that trap heat.

- Having processing opportunities for your vegetables is a huge help in decreasing losses and getting the most value out of your harvest. Left-overs will not decay and damaged ones can be processed for full price.
- Farmers think packaging is not a viable option because it takes time, effort and money that in the end will not be profitable compared to not packaging.
- The farmers that really see farming as a business are more open to trying packaging solutions if it really works in maintaining quality or extending shelf life.

Appendix 5

Vendor interviews & observations

5.1 Local market visits

29-04-2024

Visit to big market in Kumasi, it is a market where they sell a big variety of food and other goods in market stalls. Small interviews were done with about 4 market women. Since a language barrier existed in some of the cases, someone was able to translate whenever necessary.

Observation & interviews summary

The market is a huge, mostly roofed area made up of wooden stalls with corrugated metal sheet as a roof. Through it runs a network of pathways where you can walk to the different areas of the market. In each area a different kind of produce is sold, there is for example a meat area, fish area, grains area, a vegetable area and much more. The vegetable area is largely roofed, therefore the vegetables are in a shaded area, except for the onions and tomatoes. These are on the side of the roofed area where they are displayed in the sun in some cases and in the shadow in other cases. Of the vegetables displayed in the sun, the vast majority has bruises, scratches or shows signs of decay. Especially for the tomatoes this is apparent. There is a big difference in vegetable quality between different stalls as well.

There are different kinds of packaging that the vegetables are kept in for transport to the market, transport to the specific market stall, displaying the vegetables at the stall and selling the vegetables, depending on the market women and their way of working. The sourcing of the vegetables is mostly through domestic farmers that operate locally and next to this some market women also import vegetables from neighbouring countries. They arrange a certain type of transport depending on the amount of produce that needs to be transported and the distance it needs to travel. This means that if a large amount of produce needs to be transported or the produce needs to travel a further distance (another city or town) transport by truck is arranged. The market women pay the truck driver for the transport who will take care of it for them. The trucks are virtually always overloaded since more transported goods mean more money. This also means that you can get lucky or not when your produce is placed on top or on the bottom of the truck. The market women usually will see the amount of damage as a result of transport when picking up the goods. The damage is not really seen as someone's responsibility but rather as a factor that you just have to deal with if it happens. If market women need to transport a smaller amount of produce, like something ranging from 1 to 8 bags, crates or baskets and the distance stays within the city, transport by trotro, taxi or tuktuk can be arranged. A trotro is a van in which the whole area behind the driver is filled with about 16 seating places. It is a form of public transport for people or goods. The decision to choose for a certain type of transport is based on whatever fits. The packaging used for transport depends on the produce and the individual preference or customs of the market women. The packaging that is used for vegetables is in the majority of the cases big plastic fibre bags that are filled to the brim with

a part of the vegetables bulging over the top, contained by a fine net that is sewed to the top (see photo's below). There are two different sized bags the large one is 75 by 150 cm when layed flat and the medium sized bag is 70 by 110 cm when layed flat. If the vegetables are more prone to damage from impact or compression sometimes big cane baskets are used. These are also filled to the brim with produce flowing over the rim contained by a net that is attached to the basket. There are different sized baskets. The large ones are about 80-100 cm in diameter and the smaller ones are 50-60 cm in diameter, but more often used for display. Tomatoes and on some occasions other vegetables are transported in big crates. There are roughly three sizes. The largest one is 80x80x80 cm, the medium one of 70x70x70 cm and the smaller one of 60x60x60. The most used at this market were the medium ones. Lastly onions are usually transported in the bags as well as nets that are of the same size as the plastic fibre bags.

When the transport arrives at the market the market women either pick up their produce at the location where the truck is parked or unload the trotro, taxi or tuktuk. From there on the produce is carried on their head to their specific market stall. Here it is displayed in a variety of ways, depending on the individual preferences and customs of the market women. There are a variety of baskets, buckets, dishes and bowls. Black plastic buckets with a diameter of about 40cm are used for a variety of vegetables but mostly for tomatoes, onions and potatoes. Then there are different kinds and sizes of metal trays or bowls with varying depth. These are often used for cucumber, green beans, bell peppers, chillies and more. These vegetables are also often displayed in cane baskets. Sometimes the larger ones are used and sometimes the smaller ones. They are either displayed in the baskets used for transport or the transferred to smaller baskets for display at the market. Lastly, the vegetables are also displayed by placing them on the table at the stall. Next to this in some cases plastic baskets are used but not often. The table is usually covered with one of the fibre sacks used for transport, on which the vegetables are then displayed.

When there is a consumer that wants to buy a vegetables the bargaining starts. The price depends on demand and supply and next to this highly on the appearance. Vegetables with bruises, other damage or signs of decay sell for less money, about half of the price. The nice looking bigger vegetables get sold first and the damaged ones last or not at all. Once the deal is made the market women puts the vegetables in a non-see-through thin plastic bag. On the vegetables market there was one case of prepackaged vegetables, in this case a bag of small cucumbers. These were packaged because they were organic or said to be organic, there is no proof. This means they also sell for more money. The reason that the vegetables were are not prepackaged has multiple reasons. The biggest one is that people say it is a big hassle. It takes time and effort they do not want to spend on packaging since it does not really serve a benefit in their eyes. Next to this sturdy plastic packaging materials cost extra money and why spend the money, time and effort on it when you can also sell them unpackaged.









When driving around a truck transporting tomatoes was spotted:



Conclusions local market visit 1

- A large amount of vegetables displayed at the market are damaged, mostly because of transport or laying in the open sun. Tomatoes look the worst and cabbages also look damaged.
- High-quality vegetables with nice appearance sell first, as well as bigger ones. The damaged ones go for about half of the price or do not get sold at all.

- There is almost no prepackaged vegetables at the market, only a single case where the vegetables were packaged in a clear plastic bag and said to be organic.
- All packaging used for transport is filled to the brim and more. Then it is placed on an over loaded truck where many vegetables endure high amounts of pressure.
- Vegetables get mostly transported in big plastic fibre bags on trucks, sometimes cane baskets are used and wooden crates are used for tomatoes.
- Market women arrange transport of vegetables to the market with transport drivers. They either pick it up from the truck or take it from the trotro, taxi or tuktuk they transported it with.
- Transport is arranged based on amount of produce, distance and personal preference and mostly choose whatever fits.
- Display at the market is done on the table, in cane baskets, metal bowls or dishes, plastic buckets, fibre bags, crates or really occasionally in plastic baskets.
- When vegetables are sold they are put in a plastic bag for the customer.
- Most market women say pre-packaging is a hassle in which you have to invest time, effort and money, while you can also sell the vegetables without packaging. There is not really a reason or a benefit to do so they say.

07-05-2024

Visit to a vegetable market in Kumasi. This market is mostly active during the evening, during the day fewer stalls are open than in the evening and there are fewer customers. Small interviews were done with about 5 market women and 2 customers were interviewed. Since a language barrier existed in some of the cases, a translator was able to translate whenever necessary.

Observation & interviews summary

The market is largely roofed and for now empty since it is during the day. This is the time where some trucks arrive to supply vegetables to the market. The trucks arriving during lunch time are the trucks that have to come from further away since they need time to drive back. The local vegetables arrive by truck later in the afternoon. At that time the market will be fully occupied and the selling of vegetables and fruits will happen in the evening. Almost all the domestically grown vegetables arrive in big bags on trucks. This is arranged by the middle women/traders. They have arrangements with farmers, drivers and market women for the buying, transporting and selling of vegetables.

Usually the market women arrange that a driver goes around with them to pick up produce at different farms. This is because the majority of the time it is not possible for one farmer to fill a whole truck since they don't have the capacity. The market women therefore buy produce from different farmers and arrange transport to the market. There at the market the vegetables are sold to market women per bag. Usually if a market woman is in need of certain produce they call the middle women in advance to ask for a specific vegetables they need and when a



new truckload will arrive. Then the arrangement is made and when the truck arrives the market women can pick up their order at the truck. It can also be brought to other market stalls along the road by different forms of transport such as small pick-up tricycles (see picture). Some produce, mainly some fruits, are imported. Some of them are transported in corrugated fiberboard boxes. These boxes are reused by the market women for other purposes like displaying vegetables or carrying stuff in the boxes. Additionally in some cases the market women will pick up vegetables at the farm themselves. It really depends on the situation if they will do that, for example if they really need something now that they don't have at their stall anymore. The benefit is that buying directly from the farmer is way cheaper, but it also costs time and money to get there and back with the produce.

After the market women bought the bags of vegetables they transfer them to other containers such as plastic and cane baskets. They do this to allow for ventilation and to lessen the compression that happens in the bags. In this way the vegetables maintain their quality better. Other tactics used to maintain the quality are displaying some of the vegetables on dried banana leaves. In this way they bruise less and look more appealing. Sometimes these leaves, either dried or fresh are used as well to put in between layers of vegetables to prevent that several layers of vegetables are touching which will decrease ugly spots. Some vegetables are put in small baskets and some in big ones with a smaller can inside to measure produce. By diving the produce over different smaller baskets and by using the cans to measure, market women can estimate for how much they have to sell their produce compared to what they paid for it in order to make profit. Occasionally some vegetables or fruits are displayed in plastic bags at the stall for the same reason. In this way they can make sure to make profit.

Around this time of the year (beginning of May) the vegetables are really expensive. There has not been rainfall for a long time so it is hard for farmers to grow their produce. This means that the ones that do grow vegetables now can sell it for more money and the rest of the demand for vegetables is met by import. This also means that right now is one of the most expensive times in the year to buy vegetables.





Prices

At the moment one kg of red or yellow bell peppers is sold to the market women by the middle women for about 110 cedi (+/- €7,5) and sold to the customer by the market women for 120 cedi (+/- €8,3). A kilogram of green bell peppers is sold for about 20 cedi (+/- €1,4) at this moment, while the price will drop to 14 cedi (+/- €1) during the wet season when the vegetables are available in abundance. Tomatoes go for about 35 cedi (+/- €2,4) per kg while they will sell for 20 cedi (+/- €1,4) in the wet season. The price fluctuates depending on when the rain falls so it is hard for the market women to give an estimated price per month. Next to the normal vegetables, some stalls offer organic varieties of some vegetables. These are usually displayed in plastic bags at the stall. A bag of 1 kg organic tomatoes currently sells for about 50 cedi (+/- €3,4).

Customer preferences

Customers mainly pay attention to a combination of three important factors: perceived quality, size and price. It depends a bit on the customer and the use goal of the vegetables which of the factors are more important. If the produce is for example bought to be used in dishes that are sold near roads or in some restaurants it is mainly important that the vegetables are cheap in order to make more profit. Damaged vegetables usually go for about ¼ or 1/5 of the price of vegetables that have high-quality appearance. Usually if the vegetables are bought for home consumption or similar uses the more important factors are size and perceived quality. The perceived quality is based on how the vegetables look, so how much scratches, bruises and other damages are visible, does it look spoiled or does it have brown spots. Market women also indicate that vegetables that usually get sold first are the big-sized, high-quality looking vegetables. Only a very small amount of people have interest in buying organic vegetables. There are three reasons for this. The first one is that a

large amount of people are not aware of benefits of organic vegetables versus regular vegetables. Next to this there is no visible difference between organic and regular vegetables except for the plastic bag around it in some cases. On top of this the price of organic vegetables is significantly higher and can range from a price that is about 1,5 to 3 times higher than regular vegetables. Since many people in Ghana do not have very much to spend organic vegetables are not attractive to buy.

Conclusions market visit 2

- Middle women/traders arrange the buying of vegetables and the transport to market. They have the overview of a network of farmers that function as suppliers and a network of market women that will buy the vegetables from them.
- The produce is transported in big bags to the market, there market women will pick up the order they placed and take it to their stall. Some of the produce is also taken to other stalls across the city by tricycle.
- Market women transfer the vegetables from bags to baskets to enable ventilation and maintain quality of the vegetables. Next to this some vegetables are displayed on dried banana leaves and fresh banana leaves are used as a protection, both to maintain quality of the vegetables.
- Some imported vegetables or fruits arrive in cfb boxes. These are reused by market women for other purposes.
- There are some occasions where produce is displayed in plastic bags, this is done by the market women to estimate quantities and the price they have to ask in order to make profit. This is used as a sort of measurement to determine the price for different amounts of produce. This is also done by placing items in certain baskets or measuring produce with certain size baskets.
- Vegetables are sold for about $\frac{1}{2}$ to $\frac{3}{4}$ of the current price as compared to during the wet season. This time of the year is an expensive time for vegetables since there has been a long dry period which means it is hard to grow vegetables.
- Damaged vegetables go for about $\frac{1}{4}$ of the price of good-quality vegetables.
- Organic vegetables are about 1,5 to 3 times more expensive than regular vegetables.
- Customers pay most attention to perceived quality by appearance, size and price when buying vegetables. Large, good-looking vegetables get sold first. The damaged, cheap vegetables are usually sold to people who prepare food on the side of the road.

5.2 Interview Entrepreneur in crop processing

26-04-2024

Co-CEO of Honey Child Enterprise, a food/Agro-processing firm that processes maize, rice, oats, millet, sorghum, wheat, tiger nut, carrot into breakfast cereal products, ACHI alumnus.

Meeting transcript

A: Okay, so was it nice this morning?

T: Yes, I am actually an alumni for the program. So that was the third batch. Right here, so right from our batch I've been around to assist, not as a teacher, but something I come around to assist with with everybody.

A: Ah, nice. And then you can help them with some?

T: Yes, with my expertise, my knowledge with the program.

A: Okay, so before you did the program, you were also a former already, or not yet?

T: Yes, so I'm actually an entrepreneur. I'm a high-grade business. So I'm to food processing. So basically, Honey Child Enterprise, a food processing firm that produces breakfast cereals. With the aim of satisfying the health needs of our clients. So we produce these nutritional breakfast cereals for babies. And then we have the exclusive breastfeed that's six months up to adults. So that's what we do.

A: Yeah, so then maybe you source the product you get from people and then you process it and package it yourself?

T: Yes, please. So that's what we do. So we actually get raw materials from our farmers. We bring them to our processing plant. We add the value here, value of the seed. We add value to it and then give it back to our clients so that they also have something to eat to satisfy their hunger as well as promote their health.

A: Yeah, because then you also, like from the farmers you get the material, do you also have like any standards they need to meet?

T: Yes, we do. Especially with the moisture content. You know cereals, yes. Once we are processing them and then we have the duration or the shelf life of the product. So for cereals, our estimated shelf life is supposed to be on the shelf for a year. But we find it in any kind of discoloration, wood, so we check for all those stuff. We actually accept raw material. Yes, also because you put it on the packaging maybe that it's healthy and then it also needs to be good.

A: Yeah, so maybe for like getting the material and stuff, how do you usually get it? Like do the farmers, do you get it from the farmer? Does the farmer put it on the truck or they bring it to you?

T: Yes, so what we do is for the first time that we want to do at least, they really come to you please.

Do the required inspection and whether you meet the standards in the past. So once we go through that in past or standard requirements and then we have, what may say, an agreement with you. Yes, so once we have the agreement with you, then you actually be picking them, but sometimes to maybe because of time constraints and other things, then we will let you bring the product. But once it comes to, we have to make sure, is there a standard that we requested from you.

A: So yeah, I heard like from people that you have the wet season and the dry season for growing and that the price is different then.

T: Yes. So what we do is with the pricing, you know that you need to be careful with your cost of production. And cost of production, start right away from where you get your raw materials, their transportation logistics, everything comes into play. Yes. Including the labor and everything, even the maintenance of your equipment and all those things becomes into play. So we actually make sure after the dry season we know the actual input maybe out of season and therefore the prices may be high. But usually we purchase, we take advantage of the season ones. So once the product is in season, we actually buy them in bulk and store. But in case when we still need to go in for it, then we will negotiate. But that's one to try to make sure that we get it at price that we won't also inflate the prices of our final product too much. It will be difficult for the customer to purchase. But one thing that we are most concerned with is quality. So we want to maintain the quality. And if we maintain the quality and then it comes that we have to increase the price, then we increase the price a little bit with the same quality. Doing that, your customers become willing to pay because they know what they are getting. They know they are getting the quality. Maybe at a higher price than what they were buying before, but still the same quality so they will still be willing to purchase. But once you say that, oh, the raw materials are expensive now. So let me actually reduce the quality so that I can still maintain the exact price. Then people, your customers begin to get the size of it. They are not getting the value for the product. They begin to add alternatives which will also affect your business. So we prefer maintaining the quality and then if we have to increase the price, then we do.

A: So then the quality is just above everything for the consumer as well.

T: Yes.

A: And it's all stuff that has to be packaged, right? So do you do that at the processing plant as well or how does that happen?

T: So once it comes in, goes through a process, once it goes through the process, to the final product that we have and then it's wind packaged into the various packaging materials or pouches that we have. So we get that one from outside, so that is what we mean, so that one is actually imported.

A: And what kind of like material is it, is it plastic or?

T: Oh, so it's mostly ziploc. Okay, so we have a whole system that we pass through to fill them up.

Ah, yes, so it goes at the moment?

A: Yeah, and the, you just order the ziploc bags plain? Or is there already some marketing on there?

T: Okay, so for now it's plain. It comes then then we do the design and everything on it. At the factory you put it on. Yeah, so that one too, you know it's a whole value chain and so when it comes to business you have an income that you generate from direct and indirect. So what we are doing is also to make impact. So along the line or the value chain we are also helping other people's business.

So there are people who also do the packaging, the design and everything. So that's a way they also generate their income to support their life. So we have people who do it for us. Basically we don't do the design ourselves. So we have someone that we have, yes, so they do it for us.

A: And is it like a sticker you put on or?

T: Yes, let me show you. So before we are going to put on the chips, that one is already branded. Yeah, because that's the one that is sealed as well. Okay, so these are different pouches. So we have different pouches so that the price may also be affordable to each one. So when you go there you will be able to afford whatever that you want. So these ones, the prices are lower than these ones. Yes, but it's the same product. So this is a 1kg. So this is a 700g, this is also 1kg. So we have, it ranges from 700g to 800g, 1kg, 1.5kg and 2kg. And then they all have different packaging and they get more expensive. This sticker. Every information about the product is actually there.

A: Also the farmers or?

T: No, no, no, the farmers are not included.

A: Is that also, what do you think is important for the customer? Like what do they want to know from the packaging?

T: So they want to know the ingredients in there. The best before date. Another term would be the expired date. But for food processing we usually use best before. Okay, so the location or where the products actually come in from. So the location of the factory. And also the contact numbers if they want to contact you. And also another instruction is how the product is being prepared and then the storage. And then the storage, how they store it. Okay, so it should be out of sunlight. So it should be cool and free from the dust.

A: So I was maybe because for my project in the end I'll be looking at packaging for vegetables. So I was wondering if you maybe have any experience with that or if you know any people.

T: Very, very, very, very well. That's why I love the ACHI program. Farming as a business. I think the major problem that these farmers experience is not only the vegetables, but the major is actually them not doing it as a business. Because they don't calculate the amount that they are actually putting into the business. But they expect the profit margin and do all the things. That's why, so that's why sometimes they just leave their produce to just go waste. Because if you know that I'm putting in this amount of money, I am expecting this. You actually go the extra amount to get what you expect. Yes, but most of the time, oh, they just want, like something that they can just survive on.

And I think farming should be a way, I am aware of that. So you go there and then you see most of these tomatoes on the ground and get them. So my friend was there and then he just realized, when we can do, I mean, this community where it's not just about, and she always go and you see losses.

And then these farmers will just be crying upon you and sometimes because the produce is going bad, these markets will just come in and they give them any price they want. If they leave it there, they don't have any other way to sell them. The produce will go waste. So rather the price that they give them, whether it will help them or not, they just give it to them and they also will go their way.

So he told them, okay, now these produce that are going to waste, he will not let them go waste. So actually after the market women have come and pick whatever they want to pick, the rest that are maybe the sizes, maybe smaller, sometimes to baby, they will have small cracks, but not really small. They will then go you for them. So he goes in for those ones and then brings it into his process center. Then turn them into a tomato powder. And then in the base or powder and then you can get actually more money for that again. So that's what he has been doing. And I think he has given hope to the farmers because they know once the women come, they are able to sell the highest or the high value tomato to them at the price that they will negotiate. And when this comes to the low, they know they have an alternative. Someone will buy it. And when it comes to the packaging of these vegetables, I think the material that you are using to package your product, not only vegetable, but every product you are using, you have to actually look at the material and the kind of product you are making, what you will see with it. And if you go and you see the packaging material someone is using and you see, oh, this is a nice, but I want to use it, maybe it may not be good for the kind of product you want to actually continue. Yes, it's really important to, like, every vegetable has some different conditions that it goes well by. So, yeah, it's different for every vegetable.

A: Yeah. I think that were my questions.

T: Okay.

A: Yeah, well, thank you very much.

T: You're welcome.

Conclusions interview Theophilus Owusu Ansah

- For the consumer quality is most important, it goes above price. It is better to keep the same quality and rise the price a bit than to keep the price with lower quality, especially if you have a client base that knows you. You can build your brand by maintaining quality.
- All packaging material used is plastic, in this case ziplock bags ordered online from another country.
- Important information on the packaging is best before date, location where the product comes from, contact details, storage instructions, ingredients.
- It is important to meet product standards for your business.

5.3 Supermarket visit, Shoprite

19-04-2024

Shoprite supermarket in Kumasi city mall

Photo's







Prices

1 € = 14,32 GH¢ (conversion rate on 19-04-2024)

Vegetable	Packaging	Price and unit in GH¢	Approximate price in euro per kg
Tomato	Plastic foam tray + plastic film	24,99 per 4	4,35
Tomato	Plastic bag	21,99 per +/- 10	2,31
Tomato	Unpackaged	54,99 per kg	3,84
Eggplant	Unpackaged	7,99 per kilo	0,56
Cabbage	Wrapped in plastic film	24,99 per cabbage	1,74
Lettuce	Plastic sleeve	7,99 per lettuce head	2,24
Onion	Net	34,99 per kg	2,44
Spring onion	Plastic sleeve	4,99 per bag	1,75
Red pepper	Net of 5	11,99 per 100g	8,40
Red & yellow pepper	Unpackaged	299,99 per kg	20,95
Green pepper	Plastic bag	15,99 per 6	1,67
Okra	Plastic foam tray + plastic film	6,99 per +/- 25	1,96
Cucumber	Unpackaged	9,99 per kg	0,69
Cucumber	Plastic foam tray + plastic film	6,99 per 2	1,22
Chillies (green)	Plastic foam tray + plastic film	15,99 per +/- 20	2,10

Interview & observation summary

The situation in the supermarket can be compared to Dutch supermarkets although there are some differences. Overall the same vegetable is sold in different kinds of packaging, and different amounts and unpackaged vegetables are also sold. Some vegetables are in a cooled section while others are not. Almost all vegetables look of rather good quality, although most vegetables, especially the tomatoes and peppers have some dents and soft spots. Apart from that the eggplants have quite some scarring on them.

The most used packaging is non-stretchy plastic bags, then plastic film with or without a shape-retaining foam tray, nets are also used for potatoes, onions and peppers and lastly there are some plastic containers which are mostly used for pre-cut vegetables. You don't see any cardboard and the vast majority of the packaging is has a supermarket logo on it. On the packaging of the supermarket, the barcode and the product are mentioned and a logo of the supermarket. The unpackaged and some of the packaged vegetables are displayed in plastic crates with ventilation holes. For the unpackaged vegetables there are plastic bags to package them in when taking them home. The supermarket employee tells that all the vegetables in the supermarket are supplied to them by Freshmark. Freshmark is a company that operates across the African continent as a buyer and distributor of fresh fruits and vegetables. They source their vegetables from local farmers across Ghana and sort and package the produce in the distribution centre in Accra. From there packaged and unpackaged vegetables get distributed to Shoprite locations across the country. Shoprite then sells the vegetables and if they are not sold and for example start to spoil they are thrown out as waste. In the supermarket there are signs that display the farmers in Ghana they are working with to supply the supermarket.



The bundles that are made are comparable to the Netherlands, and would likely be family-sized servings. Prices vary greatly between vegetables but also for the same vegetables in different packages. For example, the unpackaged red and yellow pepper is about twice as expensive as the packaged one and for tomatoes, the unpackaged ones are more expensive than the ones in a plastic bag but less expensive than the ones in a foam tray with plastic film. The price mostly depends on a few factors. First of all the demand, sometimes when demand is high but supply is low Shoprite raises their prices for certain items. Next to this prices have to do with size and ripeness. Bigger vegetables are for example more expensive, also because it takes a longer amount of time to grow them. This explains the price difference for tomatoes in different packaging. The unpackaged ones are bigger than some packaged tomatoes. Also the look of the vegetables plays a role. The 'prettier' or less damaged it looks the more expensive it is. Lastly the ripeness is also a factor. The green bell peppers are for example less expensive than the yellow and red ones. The yellow and red bell peppers have had to ripen for a longer amount of time resulting in a higher price.

Conclusions Shoprite interview & observation

- By far the most used packaging materials are non-stretchy plastic bags and plastic film. In all cases of packaging, plastic is used.
- The vegetables looking most damaged of which the damage seems to come from physical impact after harvest are tomatoes and peppers. The eggplants have scarring but this usually has to do with pre-harvest practices.
- In shoprite plastic crates are used for moving vegetables around.
- Vegetables in Shoprite are supplied by Freshmark, a company that buys vegetables from mostly domestic farmers, packages them and distributes them to the supermarket.
- There are a few factors that determine a higher price for the vegetables. Higher demand and low supply brings a price raise and bigger, less damaged and more ripe also mean a higher price.

5.4 Supermarket visit, Melcom

29-04-2024

Melcom supermarket in Kumasi, one Melcom employee was interviewed about vegetable, sourcing handling and packaging

Interview & observation summary

Melcom supermarket sells a variety of vegetables. The ones that were available at the moment of the visit were all packaged in some form of plastic. They do also sell unpackaged vegetables but they were not available right now because they were not in stock. Currently only onions were available without packaging. The supermarket says that offering both packaged and unpackaged vegetables has advantages. By selling unpackaged vegetables it is easier for customers to choose their own quantities. Selling the packaged vegetables offers a convenient way of buying certain portions. Next to this they choose to sell packaged vegetables because it looks more appealing. Overall, they say that the majority of the supermarket customers go for the packaged vegetables. The supermarket says that it is usually perceived as higher quality since customers know vegetables that are packaged go through more processing such as cleaning and sorting. Packaged vegetables are also more perceived as organic vegetables, since it is customary to package organic vegetables. However there is no way for the customer to know for sure whether something is actually organic or not. There is no indication on the packaging or quality mark to know for sure. What does help is that there is a logo on the packaging with a phone number. This helps with traceability and makes it a bit more trustworthy since you could call or visit the supplier. Next to this, putting a phone number on the packaging means that the farmer/company is willing to take responsibility for their product/is proud of it. This means that because of the appealing look and higher perceived overall quality of the vegetables the supermarket can ask more money for the vegetables than when they are not packaged.

The larger part of the vegetables at the supermarket is from Fresh from farms. Melcom asks her to package the vegetables in her own packaging and deliver it to the supermarket. She is the only supplier of local vegetables for Melcom in Kumasi. In other cities where Melcom is located they also work with farmer which they ask to package and deliver the goods themselves. The reason for this is that it is convenient for Melcom to receive it like this since they don't have to spend time on packaging. Their main concern is receiving good quality vegetables they can sell for a good amount of money, therefore if the farmer delivers this the supermarket is satisfied. The other packaged vegetables that are sold are imported from neighbouring countries such as Burkina Faso and Togo. These vegetables arrive in big sacks or crates at the storage centre of Melcom in Accra. There they are packaged and transported to other Melcom facilities in Ghana.

The majority of the vegetables is displayed in the cooling compartment (without doors). You can see that in all the plastic bags that the vegetables are packaged in condensation has formed. This means the ventilation of the packaging is not sufficient even though she cuts the corner of the plastic bags. The price at the supermarket is fixed throughout the year.

Photo's



Prices

1 € = 14,32 GHC (conversion rate on 19-04-2024)

Vegetable	Packaging	Price and unit in GHC	Approximate price in euro per kg
Cucumber	Plastic bag with tied string (Fresh from farms)	19,49 per kg	1,36
Carrot	Plastic bag with tied string (Fresh from farms)	16,99 per 4	2,37
Green bell pepper	Plastic bag with tied string (Fresh from farms)	16,99 per 3	2,37
Green chilli	Plastic bag with tied string (Fresh from farms)	16,99 per +/- 20	2,96
Lettuce	Plastic sleeve (Fresh from farms)	6,99 per head	1,95
Eggplant	Plastic film (Fresh from farms)	11,49 per piece	3,2
Cabbage	Plastic film (Fresh from farms)	16,99 per piece	1,18
Tomato	Plastic bag with tied string (Fresh from farms)	49,99 per 4	8,72
Red onion	Plastic net	27,49 per 3	1,92
Red onion	Unpackaged	27,49 per kg	1,92
White onion	Plastic net	23,99 per 3	1,67
White onion	Unpackaged	27,99 per kg	1,95
Red cabbage	Plastic film (imported)	24,99 per kg	1,75
Carrot	Plastic bag (imported)	32,99 per 5 (29,99 promo price)	3,46 (3,14)
Cucumber	Plastic foam tray + plastic film (imported)	10,99 per 2	1,92

Conclusions Melcom supermarket visit

- Choosing for packaging or not from the perspective of the supermarket has to do with meeting the consumers needs of buying certain quantities as well as making the vegetables appealing to receive a higher price for it.
- Supermarket customers usually go for the packaged vegetables. They are perceived to be of higher quality and sometimes perceived as organic. Consumers know that packaged vegetables go through more processing such as cleaning and sorting. Next to this a phone number helps with traceability and trust. Lastly it is customary to package organic vegetables.
- Melcom supermarket wants high quality vegetables to sell without the effort of packaging, therefore they ask the supplier to package and deliver it.
- The plastic bags in which produce is packaged have condensation form in them in the cooling compartment even though the tip is cut. There is not sufficient ventilation and moisture is formed in the packaging which can make the vegetables deteriorate faster.

5.5 Supermarket visit, Palace

29-04-2024

Palace supermarket in Kumasi

Photo's





Observation summary

For each type of vegetable there is one portion size/bundle size. In the supermarket all vegetables are packaged except the onions. The used packaging is all made of plastic and packaged by the supermarket themselves. The packaging is either a plastic bag tied with a string or plastic film. While the cucumber and chilli pepper are in unperforated plastic bags, the tomatoes, eggplants and green bell pepper are in perforated plastic bags with holes of about 6mm in diameter. The vegetables are being kept in a cooling compartment and it is clearly visible that the perforated bags form significantly less condensation than the unperforated ones. Each product contains a sticker with the name 'MTC depot' which is the name of the supermarket on google maps. The sticker contains a barcode and the price as well.

All the vegetables except the onions are displayed in the cooling compartment. Most are just placed on the shelves, some vegetables in the cooling compartment are in plastic crates and some of the onions are in wooden crates. There are also things like garlic that are packaged in nets. They all look of high quality and the only sign of bruising or damage is in the small cabbages.

Prices

1 € = 14,32 GH¢ (conversion rate on 19-04-2024)

Vegetable	Packaging	Price and unit in GH¢	Approximate price in euro per kg
Green bell pepper	Plastic perforated bag with tied string	22,99 per 500 g	3,21
Red bell pepper	Plastic foam tray + plastic film	129,99 per kg	9,08
Cabbage small	Plastic film	12,99 per kg	0,91
Cabbage big	Plastic film	46,99 per kg	3,28
Eggplant purple	Plastic perforated bag with tied string	30,00 per kg	2,09
Eggplant white	Plastic perforated bag with tied string	27,00 per kg	1,89
Onion	Plastic net	9,99 per kg	0,70
Tomato	Plastic perforated bag with tied string	12,99 per 4	1,36
Cucumber	Plastic bag with tied string	14,99 per 2	2,62
Lettuce	Plastic sleeve	7,99 per head	2,79
Green chilli pepper	Plastic bag with tied string	6,99 per 100g	4,88

Conclusions Palace supermarket visit

- This supermarket has tomatoes, eggplants and green bell peppers packaged in perforated bags with holes of 6mm in diameter. In these bags less condensation is formed compared to the non-perforated bags.
- The vegetables look undamaged and of high quality.
- The only packaging material used is plastic. Since the bags are tied and because of the way the plastic film is wrapped it is likely that all packaging is done by hand.

5.6 Packaging & prices in Ghana

Table of observed packaging and prices in different markets, supermarkets and farms.

Vegetable	Packaging NL supermarkets (observation; Wuisan, 2022)	Packaging Ghana during transport/ arrival at	Display Ghana local market (observation)	Packaging Ghana supermarkets (observation)	Price at Shoprite supermarket (GHS/kg) (observation)	Price at Palace supermarket (GHS/kg) (observation)	Price at Melcom supermarket (GHS/kg) (observation)	Price Susan sells to melcom (GHS/kg) (observation)	Price Susana sells in online shop (GHS/kg) (observation)	Price per bag from farm (GHS/bag) (observation)	Wholesale price at market (from truck) (GHS/kg)	Price at market (GHS/kg)
White cabbage	Unpackaged, plastic film, plastic bag	Bags	On the table	Plastic film	24.99 (plastic film) 12.99 (plastic film)	small 12.99 (plastic film) big	16.99 (plastic film) (Susan)	12.00 (plastic film)	10.00 (plastic bag)	800-1000		
Green chili pepper	Unpackaged, cfb tray + plastic flowpack	Bags	Metal dish, metal bowl, cane basket	Plastic bag, plastic foam tray + plastic film	29.97 (tray + plastic film)	69.90 (plastic bag)	43.48 (plastic bag) (Susan)	39.99 (plastic bag)	20.00 (plastic bag)	500	26.5 (dry season) (WFP, 2023) 15 (rainy season) (WFP, 2023)	
Cucumbers	Unpackaged, plastic film	Bags	Bag, cane basket, metal dish, metal bowl	Unpackaged, plastic foam tray + plastic film, plastic bag	17.48 (tray + plastic film) 9.99 (unpackaged)	37.48 (plastic bag)	19.49 (plastic bag) (Susan)	14.00 (plastic bag)	20.00 (plastic bag)			
Eggplant	Unpackaged, plastic flowpack, plastic film, plastic bag	Bags	On the table, cane basket	Unpackaged, plastic bag, perforated plastic bag, plastic film	7.99 (unpackaged)	30.00 (plastic perforated bag)	45.96 (plastic film) (Susan)	24.00 (plastic bag)	24.00 (plastic bag)		22 (dry season) (WFP, 2023) 16 (rainy season) (WFP, 2023)	
Lettuce	Unpackaged, plastic sleeve, plastic film	Cut-open bags that are retied	On the table	Plastic sleeve	31.96 (sleeve)	39.95 (plastic sleeve)		30.00 (plastic sleeve)	-			
Okra	-	Cane baskets	Cane basket, metal bowl, metal dish	Plastic foam tray + plastic film	27.96 (tray + plastic film)	-	-	20.00 (plastic bag)	24.00 (plastic bag)			
Onion	Unpackaged, net	Nets, bags	Cane basket, plastic bucket, bag	Unpackaged, net	34.99 (net)	9.99 (net)	23.99 (net)	-	-		8 (dry season) (WFP, 2023) 5 (rainy season) (WFP, 2023)	
Bel pepper	Unpackaged, plastic flowpack, plastic film, plastic bag	Bags	Bag, cane basket, on the table, metal dish, metal bowl	Unpackaged, net, plastic bag, perforated plastic bag, plastic foam tray + plastic film	Green 23.99 (plastic bag) Red & yellow 11.90 (net) 299.99 (unpackaged)	Green 45.98 (plastic perforated bag) Red 129.99 (plastic foam tray + plastic film)	Green 33.98 (plastic bag) (Susan)	Green 24.00 (plastic bag) Red & yellow 120.00 (plastic bag)	-		Red & yellow: 110 Green: 20 (dry season) Green: 14 (dry season)	Red & yellow: 120 Green: 20 (dry season) Green: 14 (dry season)
Tomato	Unpackaged, cfb tray + plastic flowpack	Wooden crate	Wooden crate, plastic bucket	Unpackaged, plastic bag, plastic foam tray + plastic film, perforated plastic bag	62.48 (tray + plastic film) 21.99 (bag) 54.99 (unpackaged)	32.48 (plastic perforated bag)	99.98 (plastic bag) (Susan)	40.00 (plastic bag)	25.00 (plastic bag)		63 (dry season) (sourced local, ashanti) (WFP, 2023) 20 (rainy season) (sourced local, ashanti) (WFP, 2023)	35 (dry season) 20 (rainy season) 50 (organic)

Appendix 6

Consumer interviews & observations

Restaurant visits

03-05-2024

Small roadside restaurant, interview with a translator present

Summary small restaurant

The restaurant sources their vegetables at the market. Each day they visit the market to buy the vegetables they need for the day. Since they only need a small amount per day this is the most convenient. By buying small quantities per day they avoid spoilage or waste of the vegetables. The market is also a good place because there is always produce available and because they can make deals with the market women. They never buy packaged vegetables only unpackaged. The packaged ones at the supermarket are too expensive and at the market nothing is packaged. Also they see no need for buying packaged vegetables. When buying vegetables they pay attention to buying good-looking vegetables since they say they are of better quality. They do this because they want to acquire good-quality vegetables and because they cut up the vegetables and display them in a glass box at their stall. So if they are displayed they need to look good for anyone coming by to show that the quality of the food they sell is good.

03-05-2024

Medium-sized restaurant Tasty Queen, interview with a translator present

Summary Tasty Queen restaurant

The restaurant sources their vegetables unpackaged at the market. Each day they visit the market to buy the produce needed for that day. This is the easiest way to do it they say. The market is close, which is convenient. It is cheap, which is better for profit in the end and it is guaranteed that there is enough available each day to supply the restaurant. They buy it unpackaged. This is because they see no need to buy packaged vegetables and because they can buy the exact amount they need. When buying something that is packaged you are tied to certain amounts. They do not buy directly from a farmer because there are several reasons that make it less convenient for them. First of all you need to make an arrangement with a farmer that they can supply a guaranteed amount of certain vegetables each day. This is more risky than buying at the market since the farmer might experience some difficulties at some point which could result in the farmer not meeting the demands that were established. The market is therefore a safer option. The supermarket is never an option since this is too expensive.

Conclusions restaurant visits

- For small to medium-sized restaurants in a city the most convenient way of buying vegetables is through the local market. This is cheap, there is always vegetables

available in abundance which makes it reliable and you can buy exactly the amount you need.

- Restaurants buy their vegetables daily to avoid spoilage and get good quality vegetables each day.
- Restaurants buy unpackaged vegetables since they see no benefit or need for buying packaged vegetables.

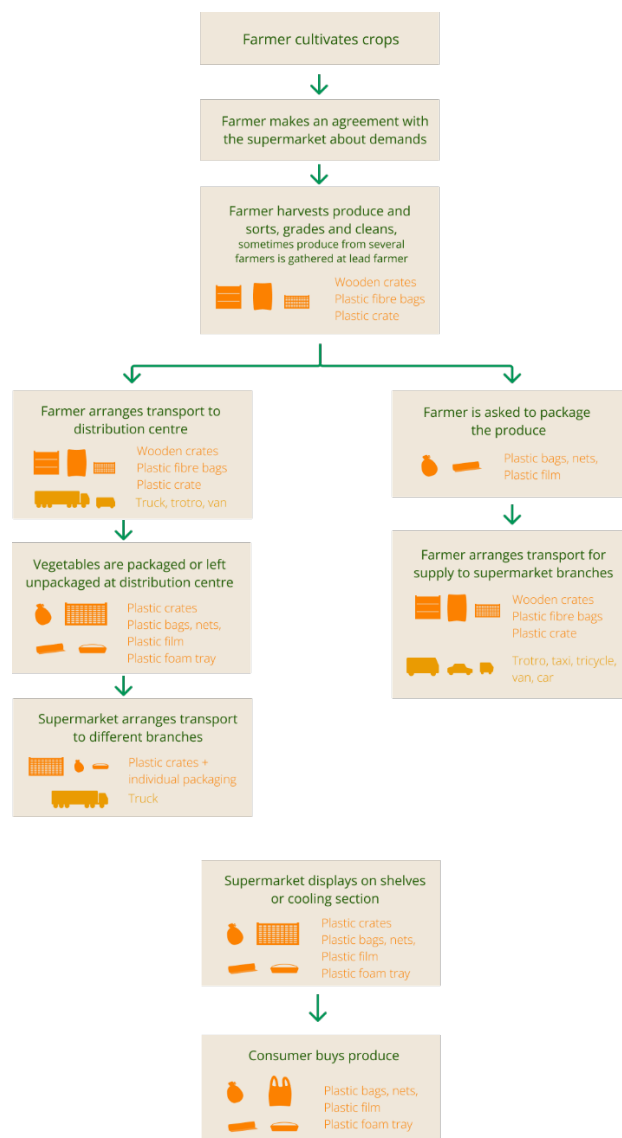
Appendix 7

Farm to consumer situations

Here the two farm to consumer situations that were not explained in detail within the report can be found.

7.1 Farm to supermarket

Part of Ghana’s vegetable retail happens in supermarkets. These are usually supermarket chains sourcing vegetables from medium to large-scale farms or from a network of small-scale farmers that can meet demands like supplying a wide variety of high-quality vegetables on a frequent basis (Arhin, 2024: appendix 1.2). This means that only commercial smallholder farmers who are organized are able to meet the demands of the supermarket. There are several supermarket chains that all operate slightly different, for this research three big ones were visited: Melcom, Shoprite and Palace.



Process from farm to supermarket

Agreement & harvesting

When selling to supermarkets first of all an agreement is established with demands that need to be met. After this the collaboration is official and the farmer will cultivate and harvest the produce. For commercial smallholder farmers there are two ways to meet the necessary numbers for supply. The first one is an organized lead farmer who buys vegetables from smaller farmers. They go around to farms to pick out the best quality vegetables and transport them to their own farm. Supermarkets only accept high-quality vegetables without bruises or damage. This means the next step is sorting, grading and cleaning. Here about 10% of the vegetables are not approved for the supermarket and are used for home consumption (Sarfo, 2024: appendix 4.3). The second way of meeting demands is by forming a cooperative of several small farmers. In this case, each farmer takes care of sorting, grading and cleaning for their own produce. Certain supermarket chains, like Melcom, ask the farmer to package the produce as well. They do this to avoid having to put the effort into packaging themselves. For the farmer this adds value since packaged vegetables can be sold for more money and it allows the farmer to establish a recognized brand, attracting more customers to the farm as well. The packaging is done in plastic bags that are tied with a string so it can easily be opened when vegetables go bad. The choice for plastic bags is made since they are widely available and only cost a small amount of money compared to the produce.

“If you have five pieces of tomatoes and just one of them is going bad. It's soft, so they just untie this. So if you seal it and tie it, it will be difficult for them. They want to be sure that the vegetables are in good condition all the time.” (Sarfo, 2024: appendix 4.3)



Packaging station at farm



Packaged green bell pepper for the supermarket

Transport

When the vegetables are ready to leave the farm they are packaged in plastic fibre bags, wooden crates or more often plastic crates and transported to the supermarket firm by the farmer themselves. Since farmers do their own transport it pays out to invest in plastic crates. Farmers have control over a large part of the value chain which means crates do not get lost or stolen which would be a risk of using plastic crates when supplying the local market. They are expensive compared to wooden crates or bags but maintain the quality of vegetables way better (Addai, 2024: appendix 4.4). If the supermarket asks the farmer to supply packaged vegetables the farmer transports them directly to the different branches. If the farmer supplies unpackaged vegetables they need to be transported to a distribution centre. In the distribution centre produce will be sorted and cleaned again and either packaged

in packaging with the supermarket logo or be left unpackaged. It will then be distributed to different supermarket branches by the supermarket firm. All supermarkets use plastic crates.



Plastic crates for fresh vegetables

Price

Farmers are paid monthly and receive a fixed price per kg of vegetable throughout the year. The farmer therefore needs to account for the varying prices as a result of demand and season themselves.

“So all we do is leave it on that balance. So when the season is in and you have it in abundance, it's an advantage for you. And when the season is on the low side, you have to balance it” (Sarfo, 2024: appendix 4.3)

The prices for which vegetables are sold at the supermarket are fixed. Only occasionally prices are raised when there is a high demand and low supply (supermarket employee, 2024: appendix 5.3). Overall less damaged and more ripe vegetables have a higher price. Specific prices and packaging for the major vegetable crops in Ghana can be found in appendix 5.6. Supermarkets sell vegetables in packaged form to meet the needs of their target group. Customers visiting the supermarket often go for packaged vegetables rather than unpackaged ones. Supermarkets indicate that this is because packaged vegetables look more appealing and are perceived to be of higher quality (supermarket employee, 2024: appendix 5.4). When vegetables are packaged they go through more processes such as cleaning and sorting. Next to this, they are traceable because contact details are provided which increases trust.



Fresh from farms vegetables in Melcom



Red bell pepper packaged individually

Packaging

All packaging observed in the supermarket was made of plastic. Most common are plastic bags and plastic film and also plastic foam trays and plastic nets are used. All packaged vegetables look like they are of high quality. In the supermarket the shelves are cooled which is beneficial for maintaining quality, however, most plastic bags used are non-perforated which results in condensation inside the bag. The moisture will increase the deterioration rate of the vegetables. In one supermarket perforated bags were used where significantly less condensation formed in the bags (supermarket employee, 2024: appendix 5.5). Most unpackaged produce looks of high quality as well. The vegetables that do show some bruising or shrivelling are tomatoes and bell peppers.



Unpackaged vegetables section



Packaged vegetables in the cooling



Unperforated bag with condensation



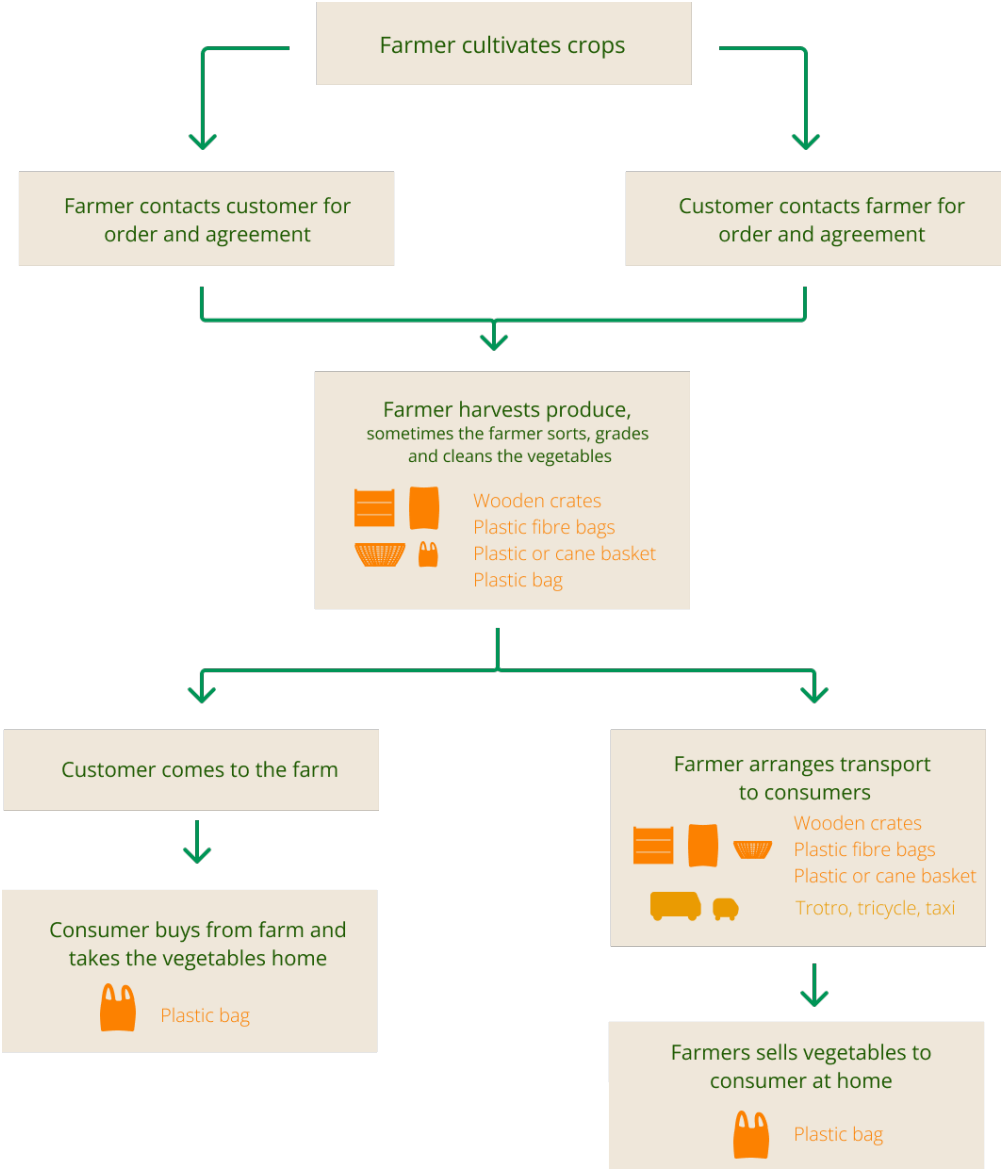
Perforated bag with less condensation



Suppliers highlighted at supermarket

7.2 Farm to consumer

Some farmers focus their business on selling directly to consumers. Often these are friends and family or a fixed customer base that is built up over the years. Such a direct link allows for farmers to receive a higher price than when selling to middle or market women but does ask for a little bit more effort in organizing sales.



Process from farm to consumer directly

Agreement & harvesting

When selling directly to consumers the farmer either calls their clients to see if they want to place an order or the client calls the farmer if they need something. When the agreement is made the farmer will harvest the produce and usually also sort and clean. By sorting the farmer can increase their profit because they can ask more for bigger, less damaged vegetables. After cleaning the vegetables are packaged in plastic fibre bags, wooden or plastic crates or plastic or sugar cane baskets.



Farmer harvesting green onions
green onions



Farm employee packaging

Transport & packaging

To receive the vegetables the consumer either visits the farm or the farmer transports the produce to the consumer. If the consumer comes to the farm they can pick up the order which the farmer packages in a plastic bag. If the farmer has to take care of the transport the vegetables are either packaged in fibre bags, crates, baskets or small plastic bags depending on the order size. Transport is either done by car if the farmer has one or by public transport in the form of a taxi, trotro or tricycle. When the farmer has to take care of transport the consumer pays extra money for this. The price is bargained for and again depends on the season and demand.



Transport by tricycle

Appendix 8

Optimal vegetable conditions

Table with optimal storing conditions for major vegetable crops in Ghana.

Vegetable	PHL percentage in Ghana	Optimal storage temp	Optimal storage humidity	Ethylene production ($\mu\text{l C}_2\text{H}_4/\text{kg}\cdot\text{h}$ at 20°C)
Cabbage	mechanical damage for individual samples: 55% farm, 32% wholesale, 45% retail market, (Kitinoja & AlHassan, 2012) 60%	0°C - 1°C (Zainalabidin et al., 2019)	95% - 100% (Zainalabidin et al., 2019)	< 0.1, Very low (Adewoyin, 2023).
Chilli pepper	16.3% (Osei-Kwarteng et al., 2018)	7°C - 10°C (Zainalabidin et al., 2019)	90% - 95% (Zainalabidin et al., 2019)	0.1–1.0, Low (Adewoyin, 2023).
Cucumbers	-	8°C - 11°C (Zainalabidin et al., 2019)	90% - 95% (Zainalabidin et al., 2019)	0.1–1.0, Low (Adewoyin, 2023).
Eggplant	30% (Wahaga & Arimeyaw, 2021)	8°C - 12°C (Zainalabidin et al., 2019)	90% - 95% (Zainalabidin et al., 2019)	0.1–1.0, Low (Adewoyin, 2023).
Lettuce	20% after 5 days of harvesting (Dovlo et al., 2021)	0°C - 1°C (Zainalabidin et al., 2019)	95% - 100% (Zainalabidin et al., 2019)	< 0.1, Very low (Adewoyin, 2023).
Okra	20 - 30 % (Vowotor et al., 2012)	7°C - 10°C (Zainalabidin et al., 2019)	95% - 100% (Zainalabidin et al., 2019)	0.1–1.0, Low (Adewoyin, 2023).
Onion	upper east region: 27.3% (Sugri et al., 2021) 23.9% (Falola et al., 2023)	0°C - 2°C (Tripathi & Lawande, 2019)	65% - 70% (Tripathi & Lawande, 2019)	0.1–1.0, Low (Benkeblia & Selselet-Attou, 1999)
Bel pepper	upper east region: 36.6% (Sugri et al., 2021)	7°C - 13°C (Zainalabidin et al., 2019)	90% - 95% (Zainalabidin et al., 2019)	0.1–1.0, Low (Adewoyin, 2023).
Tomato	upper east region: 27.1% (Sugri et al., 2021) 37.5% (Ridolfi et al., 2018) 30% (Krampah, 2016)	8°C - 15°C (Zainalabidin et al., 2019)	90% (Zainalabidin et al., 2019)	1.0–10.0, Moderate (Adewoyin, 2023).

Appendix 9

Packaging opportunities for Ghana

Packaging opportunities in plastic

When packaging produce in plastic there are several factors and opportunities to extend the shelf life of vegetables. Firstly, plastic packaging forms a barrier against physical impact and contamination. To enhance shelf life optimizing the gas permeability of the packaging that is based on the oxygen transmission rate of the product inside can prevent spoilage. Depending on the product the packaging may contain tiny holes for more permeability or on the other hand form a barrier that prevents permeability for products that do not need air to stay fresh (Higgs, 2019). In this case, vacuum packaging can also be used, here air is completely removed from the packaging after which it is sealed. In a study, perforated and unperforated plastic and fabric packaging materials compared to no packaging for tomatoes were tested in a tropical climate. The longest shelf life was observed in perforated plastic packaging whereas the lowest, with a span of 7-8 days less, was observed when no packaging was used (Poudel et al., 2022). Another option for extending shelf life is to alter gas levels in the packaging compared to ambient conditions with Modified Atmosphere Packaging (MAP) (Church and Parsons, 1995). Before sealing the oxygen, carbon dioxide and nitrogen levels are controlled in order to slow ripening and softening, reduce respiration and transpiration and reduce shrinking and shrivelling (Batu and Thompson, 1998). A study on using MAP for green chilli pepper at temperatures between 26-34°C showed less loss of nutrients, water and colour as compared to the unpackaged peppers (Edusei et al., 2012). Another study on the use of MAP for African nightshade showed a decrease in weight loss of 76% to 84% at 20°C as well as a decreased loss of nutrients (Tapsoba et al., 2022).

Packaging in corrugated fibreboard or paper

Corrugated fibreboard, also called cardboard, is a material often used in packaging for fresh vegetables. It has many benefits like its versatility, low cost and low weight. It is relatively strong but loses strength in high humidity. When moisture is absorbed from the surrounding air or produce it contains it can lose strength by as much as 75% (TNAU, 2011). Therefore most corrugated fibreboard is treated with coatings to reduce this, which is especially crucial for the fresh vegetable value chain which is very moist sensitive (van Marle, 2024: appendix 1.6). Next to this, some vegetables can be packaged in paper bags but again a coating is needed in most cases to do so properly.

Packaging with agricultural waste

An opportunity that has been tapped into more and more over the years is the use of agricultural waste, such as plant leaves to design bio-sourced packaging. An example of this is the company Banana Leaf Technology which uses banana leaves to create biodegradable food containers (Banana Leaf Technology, 2024). Plant waste is used because of its biodegradability, low cost and abundance in some areas. Some plant leaves can even have antimicrobial properties and the majority of leaves that are currently used to wrap foods have been proven to be non-toxic (Hounsou et al., 2022). In practice, there hasn't been any link observed between any health hazard and leaf-packaged foods (Vowotor et al., 2012). On

top of that using locally grown materials as packaging can benefit the local supply chain and expertise and add revenue by reducing losses as well as using a raw material that is cheaper than synthetic material (Tapsoba et al., 2022). An opportunity in Ghana could be the use of the plantain plant (*Musa paradisiaca*) of which Ghana is the highest producer in West Africa (Okoli, 2020). Here and in other African countries the plant apart from its fruits is usually discarded as waste, while in parts of Asia, the different plant parts are turned into valuable products with the use of processing techniques (Okoli, 2020).



Plantain trees next to the road



Plantain leaves used to wrap food in

Coatings and films

A lot of research is being conducted into the use of edible, biodegradable coatings or films to extend the shelf life of vegetables. Coatings can prevent transpiration and respiration and form an extra barrier to microorganisms and other contamination. The coatings can be made from biopolymers such as proteins, polysaccharides and lipids from different plants or animals. Unfortunately, the implementation of edible films is costlier as compared to synthetic ones and there is not yet a completely successful substitution implemented (Chettri et al., 2023).

Transport packaging solutions

Packaging liners can be identified as any material that is used to line a packaging container with the aim of preventing damage to the produce inside. Liners can function as protection against physical impact as well as form a moisture or microorganism barrier. A study conducted in Tamale, Ghana where liners made of several different materials for plastic and wooden tomato crates were field tested during transport shows that the use of any liner results in a reduced amount of damage compared to the control crates (Dari et al., 2017). A test performed in India with corrugated fibreboard liners for guava in plastic crates showed 12.5% fewer bruises in the fruits after transport (Kitinoja et al., 2012). Next to lining packaging containers, the material can also be added between layers of vegetables, creating separate layers with material for protection in between vegetables.

Bundling in smaller quantities

Currently, the majority of vegetables in Ghana are transported in big sacks and crates where they suffer damage as a result of compression within the container as well as pressure as a result of stacking the containers. Reducing the size of the containers or bundling vegetables in smaller quantities within the containers can reduce compression or impact during transport. At KNUST in Ghana, half-sized sacks of the original sacks for cabbages were tested during transport. While the

original sacks holding 70 kg of cabbage suffered 32% breakage and head-splitting, the smaller sacks containing 30 kg resulted in a reduced number of 23% (Kitinoja et al., 2012).

Appendix 10

Possible Directions for the project after research

10.1 Transport packaging improvement

Direction

A significant amount of vegetables lose quality as a result of poor conditions during transport. Here the opportunity arises to adapt and improve the current containers to minimize post-harvest loss during transport. The focus can either be on transport crates for tomatoes or transport bags for bell peppers which can also be applicable to other vegetables in bags. Improvements can be made by focusing on ventilation, padding, shock-absorption, minimized compression, liners and dust and sun protection.

Reason

This will ensure more high-quality vegetables arrive at the market meaning revenue can be maximized since damaged vegetables sell for ½ to ¼ of the price of undamaged vegetables.

Target situation

The solution would be best suited for supply to the local market but can also be applicable in farmer to supermarket and farmer to consumer situations.



Transport truck at market parking

10.2 Retail packaging for extending shelf life

Direction

Current retail packaging of fresh vegetables in Ghana is focused on increasing profits rather than minimizing post-harvest losses. This poses the opportunity to introduce packaging that is effective in prolonging shelf life. Depending on the produce options for vacuum packaging, modified atmosphere packaging, ethylene management, the use of corrugated fibre board and perforated plastic for optimal permeability can be explored.

Reason

Introducing more effective packaging optimized for specific vegetables can actively maintain quality and extend shelf-life, meaning less vegetables are wasted and farmers will have to replace less spoiled items in the supermarket. This can also strengthen the farmer's brand and extend the customer base.

Target situation

This solution would be suitable for farmers supplying to the supermarket. Since most of the options would include higher costs than simple plastic bags it would be too high of an investment for farmers supplying the local market.

10.3 Exploring options for packaging with organic material

Direction

The vast majority of packaging material currently used is made from plastic. Using organic matter as packaging material such as plant leaves can be a promising alternative. Plantain and palm leaves are familiar materials to work with in Ghana. Plantain leaves are for example used to wrap prepared food and palm leaves to provide shade to crops in the field. The options to use these materials for either retail or transport packaging could be explored.

Reason

Currently there is no waste management system available for plastics, meaning it is either discarded in nature or burned, polluting the environment. Plantain and palm however are a bio-sourced, bio-degradable material that grows fast and in abundance in the Ghanese climate. It is often seen as agricultural waste and burned if not used. The use of these plants would therefore reduce greenhouse gas emissions by decreasing plastic use and preventing the material to be burned. Lastly this type of material is also cheaper than synthetic material.

Target situation

This solution could be a fit for several situations depending on if it will be a retail or transport solution. Overall it has potential to be a cheap solution which is suitable for many farmers if it is not time intensive.



Food wrapped in banana leaf

10.4 Semi-automated packaging

Direction

Currently all packaging is done by hand, making it a time and effort intensive activity. This could be improved by introducing a machine or tool to speed up the process. It could for example be a solution to fill and close plastic bags, divide products into equal portions or help shape and construct packaging.

Reason

If packaging could be (partly) automated it would make packaging more attractive since less time and effort is lost. By making it more accessible it would become a viable option for more farmers.

Target situation

The solution would fit the best with farmers supplying the supermarket since these farmers usually have the opportunity to invest. If the solution is very cheap it could also be an opportunity for farmers selling to consumers and maybe even for farmers selling to the market.

Appendix 11

List of requirements

Below the demands and wishes for transport to local market as well as retail in the supermarket are listed. The reasoning behind the demands and wishes are explained as well to indicate why they are listed in the way they are and why they are important.

11.1 Demands & wishes transport to local market with explanation

Demands transport to local market

Functionality

1. The packaging solution reduces quantity loss (currently at 33%, (Wongnaa et al., 2023)) of tomatoes, measured in weight in kg, by 10%
2. The packaging solution reduces quality loss (bruises, breakage of the skin, rotting, currently at 55% damage (Dari et al., 2017)) of tomatoes as a result of shock, vibration, compression, scratches and punctures by 15%.
3. The packaging solution allows for ventilation (it is not fully closed)
4. The packaging solution lasts at least 6 days in normal use conditions .
5. With the packaging solution the tomato crates used in Ghana for transport can contain a minimum of 90% of the amount of tomatoes compared to the current amount

Acceptance

1. 75% of commercial smallholder farmers and market women in the Kumasi area accept the use of banana leaves as a packaging material for transport
2. The packaging solution should be acceptable to use for 75% of commercial smallholder farmers in the Kumasi area
3. The investment in the packaging solution and packaging tool pays out within 2 months
4. Packaging should not take more than 3 minutes extra per medium sized crate (70x70x70 cm)

Production

1. The farmer can use & produce the packaging solution themselves
2. Building instructions of the packaging solution & packaging tool are available for farmers to enable reproduction
3. The materials for the packaging solution & packaging tool can be obtained in Ghana
4. The farmer can get the tool produced locally

Reasoning for demands transport to local market

Functionality

1. Quantity loss, as part of post-harvest loss, need to be brought down. Most research uses weight loss for measuring post-harvest loss. Research shows that simple solutions such as liners, smaller bags etc. can reduce weight loss (Kitinoja et al., 2012). From this research reducing weight loss by 10% seems realistic.
2. Quality loss, as part of post-harvest loss, need to be brought down. Scratches, punctures, bruises etc. are easily measurable by observation and lead to total discard of the product, it is a good way to measure post-harvest losses. 15% reduction seems realistic when looking at tests with different types of crate liners (Dari et al., 2017).
3. Ventilation is important for a number of reasons. Ventilating can prevent buildup of heat, slowing down deterioration of the tomatoes. Ventilation also prevents the buildup of ethylene, an enzyme excreted by the tomato that speeds up ripening and respiration. The tomato is sensitive to this enzyme so by preventing buildup the tomato will deteriorate at slower rates.
4. Sunlight causes increased water loss and sometimes sunburn, therefore shielding tomatoes from the sun will slow down deterioration.
5. First packaging needs to be produced, this takes about 2 to 3 days, then the packaged tomatoes need to be transported which adds max 1 full day. After this the tomato is sold which takes a maximum of 2 days. This adds up to 6 days of use at least. Normal use conditions means that the solution is used as it is meant to be used. This means that the solution is used for the transport of tomatoes in tomato crates and includes the 'normal' production, loading and unloading of the tomatoes.
6. The transport of tomatoes is paid for per crate therefore the farmer wants to transport as many tomatoes per crate as possible. If a solution is added it should not take up too much room to make it profitable for the farmer. It can therefore not take more than 10% of volume in the crate.

Acceptance

1. In general the use of banana leaves as a packaging material needs to be accepted by the stakeholders directly handling the crates of banana leaves. These stakeholders are the farmers and market women. A 100% acceptance seems unreasonable since everyone has opinions, therefore 75% is set.
2. Next to accepting the use of the banana leaves, the solution specifically needs to be accepted by the target group: farmers in the Kumasi area. Again a 100% acceptance seems unreasonable since everyone has opinions, therefore 75% is set.
3. Farmers, especially the ones supplying the local market, don't have a lot of savings or investment room so payout time needs to be fast. Two months fits with normal growing seasons. Farmers will either have some money from last growing season or are going into a new growing season with a perspective on making more money.
4. Medium-sized crates are used most often. Using the solution should not slow down the process of packaging the tomatoes in crates too much, therefore a maximum of 3 minutes extra packaging time seems realistic.

Production

1. Part of the brief. The target group is the farmers, they need be able to use the solution on their own initiative when they want. Therefore the solution needs to be able to be produced by the farmers themselves.
2. Gives opportunity for expansion of the project (mine & ACHI) and helps with making a bigger impact. The instructions are also one way in which farmers can start using the solution themselves.
3. For the solution to be accessible and available for the farmers the materials need to be obtained in Ghana, otherwise the solution is not feasible.
4. When a tool is necessary for the production and use of the packaging solution it does not necessarily need to be build by the farmers themselves. It does however need to be build in Ghana in the local environment of the farmer for accessibility, availability and affordability (values of design for the majority).

Wishes transport to local market

Functionality

1. The packaging solution reduces quantity loss, measured in weight in kg, as much as possible
2. The packaging solution reduces damages quality loss as a result of shock, vibration, compression, scratches and punctures as much as possible
3. The packaging solution is applicable to as many people as possible
4. The packaging solution reduces the temperature of the tomato during transport compared to the current situation.
5. The packaging solution protects the tomatoes from dust during transport
6. The packaging solution protects the tomatoes against contamination with microorganisms
7. The packaging solution lasts as long as possible

Acceptance

1. The packaging solution pays out as fast as possible
2. The packaging solution requires as little investment as possible
3. Packaging should be as fast as possible
4. Packaging should be as easy as possible
5. The packaging solution is reusable for the same or other purposes
6. All commercial smallholder farmers and market women in the Kumasi area accept the use of banana leaves as a packaging material for transport

Production

1. The farmer can produce the packaging tool themselves
2. The materials for the packaging solution & packaging tool are obtained within a radius of 10 km of Kumasi
3. The solution is reproducible for farmers in other low or middle income countries

Reasoning wishes transport to local market

Functionality

1. The main goal is to reduce post-harvest losses so reducing quantity loss as much as possible will maximize impact on minimizing losses and increasing revenue.

2. Main goal is to reduce post-harvest losses so reducing quality loss as much as possible will maximize impact on minimizing losses and increasing revenue.
3. If more people can use the solution a larger impact can be made. This could for example entail for example farmers in other areas in Ghana, different countries in Africa or other low to middle income countries.
4. The higher the temperature the quicker the tomato deteriorates. Lowering the temperature can improve shelf life. Reducing temperature depends on many factors of which some that are not controllable such as the weather, therefore this is not a top priority but rather a wish.
5. Dust that sweeps up from the roads during transport can contaminate the tomatoes, therefore protection from dust would be beneficial.
6. If tomatoes are contaminated with microorganisms this increases deterioration and could also form a health hazard. Since this is not one of the most important factors in deterioration it is a wish.
7. The longer it can be used the cheaper it becomes for the farmer, making more revenue and saving resources.

Acceptance

1. The faster the solution pays out the more chance there is people will want to use it and the quicker they make revenue.
2. The smaller the investment in the solution the more accessible it will be for farmers with smaller investment capacities.
3. The faster you package the more can be packaged or the more time is left for other activities. It will be more efficient, increasing revenue & production rate.
4. More people will be tempted to try it if packaging is easy since it doesn't take effort. It will also be more efficient so more revenue can be made.
5. More people will benefit from the solution if it is reusable, making more impact. Next to this it is sustainable to reuse things and saves resources.
6. If there is a 100% acceptance rate implementation of the solution is easier.

Production

1. If farmers can produce the tool it will be more accessible & affordable.
2. The closer the materials can be obtained the more chance for acceptability there is as well as increased accessibility (design for the majority values).
3. If farmers can also profit from the solution more impact can be made.

11.2 Demands & wishes retail in supermarket with explanation

Demands retail in supermarket

Functionality

1. The packaging solution reduces quality loss (bruises, breakage of the skin, rotting) of tomatoes as a result of shock, vibration, compression, scratches, punctures and moisture level inside the packaging by 15 percent
2. The packaging solution allows for ventilation (it is not fully closed)
3. The packaging solution can be opened and closed while displayed in the supermarket
4. The packaging solution lasts at least 14 days in normal use conditions.
5. The packaging solution has less negative impact on the environment than using plastic
6. The packaging solution allows for branding and information giving options for the farmer
7. The packaging solution shows the tomatoes inside

Acceptance

1. 75 % of commercial smallholder farmers, supermarkets and middle income supermarket customers in the Kumasi area accept the use of banana leaves as a packaging material for retail
2. The aesthetic appeal of the packaging solution should be acceptable for 75% of middle-income supermarket customers in the Kumasi area.
3. The investment in the packaging solution and packaging tool pays out within 4 months
4. Packaging should not take more than 45 seconds per packaging quantity
5. The packaging material is cheaper than plastic bags, so packaging per bundle is cheaper than 10 pesewa

Production

1. The farmer can use & produce the packaging solution themselves
2. Building instructions of the packaging solution & packaging tool are available for farmers to enable reproduction
3. The materials for the packaging solution & packaging tool can be obtained in Ghana
4. The farmer can get the tool produced locally

Reasoning demands retail in supermarket

Functionality

1. Quality loss, as part of post-harvest loss, need to be brought down. Scratches, punctures, bruises etc. are easily measurable by observation and lead to total discard of the product, it is a good way to measure post-harvest losses. 15% reduction seems realistic when looking at tests with different types of crate liners (Dari et al., 2017).
2. Ventilation is important for a number of reasons. Ventilating can prevent buildup of heat, slowing down deterioration of the tomatoes. Ventilation also prevents the buildup of ethylene, an enzyme excreted by the tomato that speeds up ripening and respiration. The tomato is sensitive to this enzyme so by preventing buildup the tomato will deteriorate at slower rates.

3. When farmers supply to a supermarket the supermarket usually requests the farmers to replace decayed products that are packaged in the supermarket. Therefore, it needs to be possible to open and close the packaging.
4. A tomato can be stored in cooling conditions for about 16 days and room temperature of 30 for about 7 (Nyalala & Wainwright, 1998). Before packaging the tomato, the packaging needs to be fabricated. Therefore, packaging should last around 14 days for retail, this takes production, transport and retail time into account. Normal use conditions means that the solution is used as it is meant to be used. This means that the solution is used for the retail of tomatoes in the supermarket and includes the 'normal' production and packaging of the tomatoes.
5. Using banana leaves as opposed to plastic is also partly an environmental choice. Additionally, plastic has been proven to protect while banana leaves are a more novel unresearched solution. Therefore, if banana leaves are less sustainable using plastic would for example be a safer and better option.
6. If a farmer sells in the supermarket they usually sell good quality. It is very beneficial for them to market this and be recognized for this effort.
7. Consumers pay attention to appearance when buying vegetables, therefore they need to be able to see the contents of the packaging.

Acceptance

1. In general, the use of banana leaves as a packaging material needs to be accepted by the stakeholders directly involved in the retail of banana leaf packaging for retail. These stakeholders are commercial smallholder farmers, supermarkets and middle-income supermarket customers in the Kumasi area. A 100% acceptance seems unreasonable since everyone has opinions, therefore 75% is set.
2. Next to accepting the use of the banana leaves, the solution specifically needs to be accepted by the people that will buy the solution: middle income supermarket customers in the Kumasi area. Again A 100% acceptance seems unreasonable since everyone has opinions, therefore 75% is set.
3. Farmers don't have a lot of savings or investment room so payout time needs to be fast. Since the farmers that are supplying to the supermarket have a little more investment room 4 months seems reasonable.
4. Using the solution should not slow down the process of packaging the tomatoes too much, therefore a maximum of 45 seconds extra per packaging quantity seems realistic.
5. The reason for choosing banana leaves is partly that it is an accessible, cheap option. Therefore, it should not cost more than the current situation where plastic is used. One plastic bag is about 10 pesewa (about 8 cents)

Production

1. Part of the brief. The target group is the farmers, they need be able to use the solution on their own initiative when they want. Therefore the solution needs to be able to be produced by the farmers themselves.
2. Gives opportunity for expansion of the project (mine & ACHI) and helps with making a bigger impact. The instructions are also one way in which farmers can start using the solution themselves.
3. For the solution to be accessible and available for the farmers the materials need to be obtained in Ghana, otherwise the solution is not feasible.
4. When a tool is necessary for the production and use of the packaging solution it does not necessarily need to be build by the farmers themselves. It does however need to be build in Ghana in the local environment of the farmer for accessibility, availability and affordability (values of design for the majority).

Wishes retail in supermarket

Functionality

1. The packaging solution reduces quantity loss, measured in weight in kg, as much as possible
2. The packaging solution reduces damages quality loss as a result of shock, vibration, compression, scratches and punctures as much as possible
3. The packaging solution is applicable to as many people as possible
4. The packaging solution protects the tomatoes against contamination with microorganisms
5. The packaging solution lasts for as long as possible

Acceptance

1. The packaging solution pays out as fast as possible
2. The packaging solution requires as little investment as possible
3. Packaging should be as fast as possible
4. Packaging should be as easy as possible
5. The packaging solution is reusable for the same or other purposes
6. All commercial smallholder farmers, supermarkets and middle income supermarket customers in the Kumasi area accept banana leaves as a packaging material for retail

Production

1. The farmer can produce the packaging tool themselves
2. The materials for the packaging solution & packaging tool are obtained within a radius of 10 km of Kumasi
3. The packaging solution is reproducible for farmers in other low or middle income countries

Reasoning wishes retail in supermarket

Functionality

1. The main goal is to reduce post-harvest losses so reducing quantity loss as much as possible will maximize impact on minimizing losses and increasing revenue.
2. Main goal is to reduce post-harvest losses so reducing quality loss as much as possible will maximize impact on minimizing losses and increasing revenue.
3. If more people can use the solution a larger impact can be made. This could for example entail for example farmers in other area's in Ghana, different countries in Africa or other low to middle income countries.
4. If tomatoes are contaminated with microorganisms this increases deterioration and could also form a health hazard. Since this is not one of the most important factors in deterioration it is a wish.
5. The longer it can be used the cheaper it becomes for the farmer, making more revenue and saving resources.

Acceptance

1. The faster the solution pays out the more chance there is people will want to use it and the quicker they make revenue.
2. The smaller the investment in the solution the more accessible it will be for farmers will smaller investment capacities.
3. The faster you package the more can be packaged or the more time is left for other activities. It will be more efficient, increasing revenue & production rate.

4. More people will be tempted to try it if packaging is easy since it doesn't take effort. It will also be more efficient so more revenue can be made.
5. More people will benefit from the solution if it is reusable, making more impact. Next to this it is sustainable to reuse things and saves resources.
6. If there is a 100% acceptance rate implementation of the solution is easier.

Production

1. If farmers can produce the tool it will be more accessible & affordable.
2. The closer the materials can be obtained the more chance for acceptability there is as well as increased accessibility (design for the majority values).
3. If farmers can also profit from the solution more impact can be made.

Appendix 12

Questionnaire perception and use of banana leaves

12.1 Questionnaire set-up

This questionnaire was set-up to assess the way Ghanaians look at the use of banana leaves as a packaging material. The first part is the same for all participants and asks questions about the perception of the banana leaf as a material in general. After this the separation is made between whether the participants are farmers, consumers, market women or supermarket employees. To each of these groups a different set of questions is presented to see their opinion on using banana leaves as a packaging material. The questions are focussed on their experience with the packaging from their use perspective. Because the participants only consisted of farmers and consumers, these questions are visible below. The questions for market women and supermarket employees are disregarded.

Banana leaves as a packaging material


Hi, Nice to meet you! My name is Anna, a master's student Integrated Product Design at Delft University of Technology. I am currently working on my master thesis revolving around designing packaging solutions for fresh vegetables in Ghana to reduce post-harvest losses. In this form I want to ask you some questions about your opinion on using banana leaves as a packaging material for fresh vegetables. With packaging I mean any way to contain or protect vegetables during storage, transport and selling. Your honest opinion is very valuable to me. Medaase pii!

*** Verplichte vraag**

I want to participate in this research and give permission to use my answers *

Yes
 No

Example of packaging made from banana leaves



1

Personal details

First I would like to know some general things about you

Who are you? *


Farmer
 Market woman
 Consumer
 Supermarket employee

What is your age? *

Younger than 20
 20 - 30
 30 - 40
 40 - 50
 50 - 60
 Older than 60

Perception of the banana leaf
The following questions are about your opinion on banana leaves when they are used as a material, for example for packaging or wrapping food.

2



I think banana leaves are a material that is: *

1 2 3 4 5

Low quality High quality

I think banana leaves are a material that is: *

1 2 3 4 5

Unhealthy Healthy

I think banana leaves are a material that is: *

1 2 3 4 5

Expensive Cheap

Is there anything else you want to mention about your opinion on banana leaves?

Jouw antwoord _____

3

Farmer

The following questions are about your personal opinion on the use of banana leaves as a packaging material for fresh vegetables during storage, transport and selling.

Where do you sell your vegetables? (You can choose multiple) *

Local market

Supermarket

Directly to customer

Anders: _____

Would you want to use banana leaves as a packaging material for storage if it reduces damages to vegetables? *

Yes

No

Would you want to use banana leaves as a packaging material for transport if it reduces damages to vegetables? *

Yes

No

4

Would you want to use banana leaves as a packaging material for selling to customers if it reduces damages to vegetables? *

Yes

No

What are the reasons you would want to use the leaves as packaging or not? *

Jouw antwoord _____

If you would use the banana leaves, where would you get the banana leaves? *
And how much would it cost per leaf?

Jouw antwoord _____

Why are you currently not using banana leaves as a packaging material? *

Jouw antwoord _____

5

Consumer

The following questions are about what you pay attention to when buying vegetables

Where do you buy your vegetables? (You can choose multiple) *

Local market

Supermarket

Directly from farmer

Anders: _____

When buying vegetables which factors are important for you? *

	Not important at all	A little important	Somewhat important	Important	Very important
Price	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Size & weight	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Appearance (damages)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Health benefit (nutrients)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Safety (pesticide use, contamination)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6

Are there any other things you pay attention to when buying vegetables? *

Jouw antwoord _____

Which of the vegetables has the highest quality, is the healthiest and which one is the cheapest? *

A - Perforated plastic bag B - Unperforated plastic bag C - Foam tray & plastic film D - Cardboard box E - Banana leaf box

	A	B	C	D	E
Highest quality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Healthiest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cheapest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Why do you think that? *

Jouw antwoord _____

7

Which branding has the highest quality, is the healthiest and which one is the cheapest? *

A - No branding B - Supermarket branding C - Farm branding

	A	B	C
Highest quality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Healthiest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cheapest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Why do you think that? *

Jouw antwoord _____

8

Consumer

The following questions are about your personal opinion on the use of banana leaves as a packaging material for fresh vegetables during selling.

Would you want to buy vegetables that are packaged in banana leaves? *

Yes
 No

What are the reasons you would want to buy the vegetables packaged in leaves or not? *

Jouw antwoord _____

Which of these options would you buy? (You can choose multiple) *

A - Bowl or envelope B - Wrapper C - Closed box D - Half open structure

A - Bowl or envelope
 B - Wrapper
 C - Closed box
 D - Half open structure

9

What are the reasons you would want to buy them or not? *

Jouw antwoord _____

Does the colour of the banana leaf matter when you would buy it? *

Yes
 No

Which colour would you buy or not? *

A B C D

	Yes, I would buy it	No, I would not buy
A	<input type="checkbox"/>	<input type="checkbox"/>
B	<input type="checkbox"/>	<input type="checkbox"/>
C	<input type="checkbox"/>	<input type="checkbox"/>
D	<input type="checkbox"/>	<input type="checkbox"/>

Why would you buy it or not? *

Jouw antwoord _____

10

12.2 Questionnaire results

In total there were 12 reactions on the questionnaire of which 5 farmers and 7 consumers. The answers per group are visible below.

Farmers:

	A	B	C	D	E	F
1	Who are you?	Farmer	Farmer	Farmer	Farmer	Farmer
2	What is your age?	30 - 40	30 - 40	30 - 40	30 - 40	40 - 50
3	I think banana leaves are a material that is: low quality (1), High quality (5)	4	5	5	5	3
4	I think banana leaves are a material that is: Unhealthy (1), Healthy (5)	4	5	5	5	3
5	I think banana leaves are a material that is: expensive (1), cheap (5)	5	5	4	3	4
6	Is there anything else you want to mention about your opinion on banana leaves?	It medicinal	What is the shelf life of the leave once its being used as a package? Will it maintain its freshness of the product over a period of time? How sustainable is the banana left?	They are in abundance in Ghana	They turn to loose their natural colour quickly	Has there been any studies to confirm if organic matter of banana leaves can be toxic?
7	Where do you sell your vegetables? (You can choose multiple)	Local market	Local market, Supermarket, Directly to customer	Directly to customer, At exhibitions	Local market, Supermarket, Directly to customer	Local market
8	Would you want to use banana leaves as a packaging material for storage if it reduces damages to vegetables?	Yes	Yes	Yes	Yes	Yes
9	Would you want to use banana leaves as a packaging material for transport if it reduces damages to vegetables?	Yes	Yes	Yes	Yes	Yes
10	Would you want to use banana leaves as a packaging material for selling to customers if it reduces damages to vegetables?	Yes	Yes	Yes	Yes	Yes
11	What are the reasons you would want to use the leaves as packaging or not?	It medicinal	It's environmentally friendly .	i want to use it because its more natural and healthy	Due to their antioxidant and antimicrobial activities, which help preserve freshness and protect against spoilage microorganisms.	They are biodegradable thus adverse effect on environment is reduced (as compared to single use plastics
12	If you would use the banana leaves, where would you get the banana leaves? And how much would it cost per leaf?	From my backyard	I have the banana tree in my farm so it wouldn't cost me for now	from the banana farmers ,mostly its free or at a very low price	I grow banana in my farm so I will purchase at zero cost.	Locally in the farming community
13	Why are you currently not using banana leaves as a packaging material?				I have little knowledge on how to process the leave as a packaging materials.	Because no innovative has been applied to it to make bags container which can be utilised on the farm

Consumers:

	A	B	C	D	E	F	G	H
1	Who are you?	Consumer	Consumer	Consumer	Consumer	Consumer	Consumer	Consumer
2	What is your age?	30 - 40	40 - 50	30 - 40	30 - 40	30 - 40	20 - 30	30 - 40
3	I think banana leaves are a material that is: low quality (1), High quality (5)	3	5	3	5	4	4	2
4	I think banana leaves are a material that is: Unhealthy (1), Healthy (5)	5	5	3	5	5	4	4
5	I think banana leaves are a material that is: expensive (1), cheap (5)	5	5	5	5	5	4	5
6	Is there anything else you want to mention about your opinion on banana leaves?	Banana leaves have been used to safely package 'fante kenkey' for centuries. It has potential to be used for other products too.				They are readily available	I think banana leaves are organic and if used as a packaging material would help protect the environment from the pollution of plastic wastes.	
7	Where do you buy your vegetables? (You can choose multiple)	Local market, Directly from farmer	Local market	Local market, Supermarket	Local market	Local market, Supermarket, Directly from farmer	Local market	Local market
8	When buying vegetables which factors are important for you? [Price]	Very important	A little important	A little important	Important	Important	Very important	Very important
9	When buying vegetables which factors are important for you? [Size & weight]	A little important, Very important	A little important	Very important	Somewhat important	Important	Very important	Important
10	When buying vegetables which factors are important for you? [Appearance (damages)]	Very important	A little important	Very important	Very important	Very important	Very important	Very important
11	When buying vegetables which factors are important for you? [Health benefit (nutrients)]	Very important	A little important	Very important	Very important	Very important	Very important	Somewhat important
12	When buying vegetables which factors are important for you? [Safety (pesticide use, contamination)]	Very important	A little important	Very important	Important	Important	Very important	Important
13	Are there any other things you pay attention to when buying vegetables?	No	Sources	Their colour or appearance	Yes, the environment where the product is placed	Quality and freshness	Freshness	Storage
14	Which of the vegetables has the highest quality, is the healthiest and which one is the cheapest? [Highest quality]	C	E	A	C	E	C	D
15	Which of the vegetables has the highest quality, is the healthiest and which one is the cheapest? [Healthiest]	E	E	E	D	E	D	D
16	Which of the vegetables has the highest quality, is the healthiest and which one is the cheapest? [Cheapest]	E	E	E	B	E	E	E

17	Why do you think that?	Natural products are safer to use in and for food	I will pay less for package and less effect from packing material	Nothing	C packagaing material will be able to protect the product more than the rest but not healthy as compare to D and E	Because of the material the material contained in	Though C looks good and very presentable in terms of the packaging but D and E are biodegradable.	How tomatoes are package for me as a consumer is not a problem. I clean and sort them when i get home
18	Which branding has the highest quality, is the healthiest and which one is the cheapest? [Highest quality]	C	C	B	B	B	C	B
19	Which branding has the highest quality, is the healthiest and which one is the cheapest? [Healthiest]	C	C	B	B	B	C	B
20	Which branding has the highest quality, is the healthiest and which one is the cheapest? [Cheapest]	A	C	C	A	A	A	A
21	Why do you think that?	The farmer must market himself and his products as much as the supermarket also need to market theirs	Cost less	Nothing	the product A will be cheaper because there will be no label cost on the overall product	Because of the detailed labeled	The infomation on B is not that visible to read though it has a nice packaging but doesn't look so different from that of C.	With B , i have an idea where its been produced and location
22	Would you want to buy vegetables that are packaged in banana leaves ?	Yes	Yes	Yes	Yes	Yes	Yes	No
23	What are the reasons you would want to buy the vegetables packaged in leaves or not?	It's safer to consume and it's environmentally friendly	Cheap with less effect	They will look natural	this will minimize more plastic waste in my house	Because of tje healthy benefits	Because banana leaves are organic and biodegradable which will intend protect the environment but the banana package should be made well to prevent the spill off of vegetables due to tear .	Handling could be difficult
24	Which of these options would you buy? (You can choose multiple)	A - Bowl or envelope, B - Wrapper, C - Closed box, D - Half open structure	B - Wrapper	A - Bowl or envelope, C - Closed box, D - Half open structure	C - Closed box	A - Bowl or envelope	C - Closed box	A - Bowl or envelope, B - Wrapper, C - Closed box, D - Half open structure
25	What are the reasons you would want to buy them or not?	Packaging is safe and nice	Covers completely	They are attractive	product is well contain which will facilitate easily handling	To prevent heat build up	C looks more firmly and easy to handle	Each vegetable will require different packaging
26	Does the colour of the banana leaf matter when you would buy it?	No	No	Yes	Yes	Yes	Yes	No
27	Which colour would you buy or not? [A]	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it
28	Which colour would you buy or not? [B]	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it	Yes, I would buy it
29	Which colour would you buy or not? [C]	Yes, I would buy it	Yes, I would buy it	No, I would not buy	Yes, I would buy it	Yes, I would buy it	No, I would not buy	No, I would not buy
30	Which colour would you buy or not? [D]	Yes, I would buy it	Yes, I would buy it	No, I would not buy	No, I would not buy	No, I would not buy	No, I would not buy	No, I would not buy
31	Why would you buy it or not?	I'm concerned more about safety and not appearance per se	Healthy	Because of its span	because it looks fresh	Colour must be attractive	The pure green color makes the product appealing to the eye as well	Green color makes it more appealing

12.3 Conclusions from the questionnaire

Below the results of the questionnaire are analysed. First the statistics of the questions are stated for the general questions and the questions per group. After this a small conclusion follows with the interpretation of the statistics.

General

40% of respondents rate banana leaves as a high-quality material and 90 % of respondents rate banana leaves neutral or higher on quality of the material. Overall farmers rate the banana leaves slightly higher in perceived quality. 60% of respondents rate banana leaves as a healthy material and all respondents rate banana leaves neutral or higher when asked how healthy they perceive the material. Two thirds of the respondents think banana leaves are a cheap material and no one rates it more expensive than neutral.

Additional positive opinions on banana leaves that are worth mentioning are:

- *"I think banana leaves are organic and if used as a packaging material would help protect the environment from the pollution of plastic wastes."*
- *"They are in abundance in Ghana."*
- *"Banana leaves have been used to safely package 'fante kenkey' for centuries. It has potential to be used for other products too."*

On the other people also have questions that might stem from concerns. One person asked if there have been studies that confirm that banana leaves are non-toxic. Next to this there are questions about shelf life of the leaves, if it will maintain freshness of the product inside and how the banana plant is left.

Conclusion

Overall, both farmers and consumers perceive the banana leaf as a material that is healthy, of good quality and cheap. They see the benefits it could have as a packaging material and recognize the use of it in their environment for other purposes. At the same time some questions remain about the use of this material for packaging fresh vegetables.

Farmers

80% of farmers sell to their vegetables through the local market, 40% sell to the supermarket and 60% also sells directly to consumers. 60% of farmers sells through more than one channel.

All farmers would be willing to use banana leaves as a packaging material if it helps to reduce damage to the vegetables whether it be for storage, transport or selling. Two farmers state that they would like the fact that it is environmentally friendly as compared to plastics since it is a biodegradable material. Another farmer states that they like it because it is healthy and natural. Another farmer mentions that it is medicinal and another one highlights that the leaves help preserve freshness and protect against spoilage.

"Due to their antioxidant and antimicrobial activities, which help preserve freshness and protect against spoilage microorganisms."

To acquire the banana leaves 60% of farmers would resort to the plants growing on their own farm which wouldn't cost them anything. The remaining 40% would get it locally from other farmers. One farmer says this is mostly free or at a very low price.

When asked why banana leaves are currently not used as a packaging material the main problem is a lack of knowledge on the processing of the leaves for packaging combined with the fact that there are currently no innovative solutions for it to be used on the farm.

"I have little knowledge on how to process the leave as a packaging materials."

Conclusion

All farmers participating in the questionnaire would want to use banana leaves as a packaging material if it helps to reduce damage to their produce. The reason for this is that they see it as an environmentally friendly option that can help preserve freshness and could even be medicinal. The reason that it is currently not happening is the fact that the farmers currently do not know any innovative solutions and do not know how to process the leaves to use them as packaging material.

If they would use them more than half of the farmers would get the leaves from their own farm and the other would get it locally from other farms for free or at very low cost.

Consumers

100% of respondents get their vegetables from the local market. Additionally, some get them in other places as well. About 60% only goes to the local market, 30% also goes to the supermarket and 30% also buys them directly from the farmer.

Out of all factors that are important to consumers when buying vegetables appearance (damages) is the most important, rated as "very important" by 85% of consumers. Second in line comes health benefit (nutrients), rated as very important by 70% of respondents. Third is safety (pesticide use, contamination) rated for by about 40% as important and 40% as very important. Price and size & weight score almost the same, but price is seen as slightly more important. In both size & weight and price the scores are quite equally divided from "a little important" to "very important". Other factors that are also paid attention to are freshness, storage/display and the source.

Out of the presented options for packaged tomatoes the option that is declared as the highest quality by 40% of respondents are the tomatoes packaged in the foam tray with plastic film. 30% sees the tomatoes packaged in banana leaves as the ones of highest quality. The ones seen as healthiest are the ones packaged in a banana leaf box and the cardboard box with 60% choosing the banana leaf box and 40% the cardboard box. Lastly the cheapest one is the banana leaf box, chosen by 85% of the people. The reasons for these choices are the fact that the banana leaf box and the cardboard box are seen as

more healthy, safe, natural and biodegradable. People do state that the tomatoes in the foam tray with cling film look most presentable and well protected.

When looking at the perception of different kinds of branding, supermarket branding is seen as healthiest and highest quality, both chosen by 60% of respondents. This is followed by farm branding chosen as healthiest and highest quality by 40% of the consumers. 70% of respondents choose no branding as the cheapest and 30% chooses farm branding as the cheapest. Reasoning for this is very divided but overall labelling is perceived as healthier and higher quality because the production location and other details can be communicated.

85% of the consumers would buy vegetables packaged in banana leaves. Mainly because it will minimize plastic waste, is environmentally friendly and could have health benefits.

"It's safer to consume and it's environmentally friendly."

"Because banana leaves are organic and biodegradable which will intend protect the environment but the banana package should be made well to prevent the spill off of vegetables due to tear."

Out of the different packaging options for tomatoes with banana leaves 70% says they would buy the vegetables in a closed box of banana leaves. About 60% would buy the ones in a folded bowl or envelope. And 40% would buy the vegetables in a wrapper or the ones in an half open structure. The reason that the closed box would be bought the most likely is because consumers state that it facilitates easy handling, that it is safe and covers the product completely. Very relevantly a consumer also mentions that each vegetable would require different packaging.

To 60% the colour of the leaf would matter when deciding to buy the produce or not. 40% does not care about the colour. Colours on the picture marked with A and B, both looking fresh bright and dark green, would be bought by all respondents. C, which is slightly less vibrant would be bought by about half of the consumers and D, which is getting yellow would be bought by 30%. Once the leaf turns yellow consumers get more concerned about safety and freshness of the product.

"I'm concerned more about safety and not appearance per se."

Conclusion

All consumers get at least a part of their vegetables at the local market, 40% also gets their vegetables from other places such as the supermarket or directly from a farm. When buying the vegetables the following factors, stated in order of most importance are:

1. Appearance (damages)
2. Health benefit (nutrients)
3. Safety (pesticide use, contamination)
4. Price
5. Size & weight

Additionally, freshness, storage/display and the source are also paid attention to. Tomatoes packaged in a foam tray with plastic film are seen as the ones of highest quality since they seem the most well protected, while the ones packaged in a banana leaf box are seen as the healthiest and cheapest because it is more safe, natural and biodegradable.

Supermarket branding is seen as slightly higher quality and healthier than farm branding and no branding is seen as the cheapest. Overall labelling in general is perceived as better because of information and knowledge about the source of the product.

85% of the consumers would buy vegetables packaged in banana leaves. Mainly because it will minimize plastic waste, is environmentally friendly and could have health benefits. Most consumers would buy vegetables in a closed box of banana leaves since it seems easy to handle and safe because it covers the product completely. For 60% of people the leaf colour would be important when buying vegetables packaged in banana leaves. When the leaves lose their vibrancy and start to change colour concerns about freshness and safety start arising.

Discussion

The sample of 12 people respondents is relatively small and the number of respondents per group is even smaller. It is important to take this into account when reading the results and the conclusions drawn from the results. Ideally a larger sample size would have been resembled but given the timeframe and numerous attempts to acquire more respondents the results are evaluated and used with the current sample size of 12 people.

In the results all farmers state they would be willing to use a solution if it helps to reduce damage to their vegetables. In reality, the willingness to actually use such a solution would depend on more factors than just the effectiveness of the solution. Time, resources and effort put into it from their side would make a difference in the willingness to accept a certain design. This therefore needs to be further evaluated when a solution is designed.

The consumers were presented with different kinds of packaging in picture form. Therefore all responses of consumers on which packaging they would or would not buy and would perceive as high quality or healthy are responses based on pictures rather than real life experience. Having actual packaging in their hands and being able to feel and see the packaging in real life would likely elicit different answers. The results should therefore be taken with caution. Next to this some contradicting answers are given sometimes.

Consumers state for example that that appearance (damages) is the most important when buying vegetables but they also state that they would buy closed packaging in which the products are not visible from the outside. Lastly colour of the leaf is now tested with plain pictures of leaves. When a packaging looks very slick while it has a yellow colour the opinion could be very different than when just looking at a leaf. Therefore the colour of the design should be tested again if a solution for retail packaging is developed.

Appendix 13

Material exploration tests

To get familiar with the banana leaf as a packaging material and explore its characteristics several tests are conducted to look into the best ways to maximise shelf life and store & handle the leaves.

13.1 Storing tests

Start of test on 18-06-2024

Test set-up

The first test that is conducted is a test on how to store the leaves the best. For this, 15 samples were prepared and stored in different ways. First all leaves were cleaned with a wet cloth and dried afterwards. Then they were cut into samples with a knife. Out of the 15 samples, 5 were then pre-treated by boiling them in water for 30 seconds (marked with a blue tag), 5 were pretreated by holding them over an open flame until the whole surface was heated (marked with a green tag) and 5 samples were left untreated (not marked with a tag).



Then 1 sample out of each group was stored in a different way:

- At room temperature without protection
- In a sealed bag at room temperature
- In a bowl of water at room temperature
- In the fridge at about 5°C
- In the freezer at about -18°C.

Of course, not everyone in Ghana has access to cooling facilities, but it is included in the tests to also test the best way to store it myself since I cannot acquire fresh banana leaves at any given moment.

Results

Overall when applying the pre-treatments to the leaf samples it stands out that on the samples held over an open flame the leaf veins on the upper side of the leaf turn a more brownish colour while the veins of the leaves that are boiled or untreated stay green. On the back of the leaf held over an open flame dark spots are visible as well.



18-06



18-06

After two days the leaves stored at room temperature without protection all dried out and curled up to some extent, the untreated leaf sample more than the pretreated ones. The leaf does stay green and slightly flexible. Both the treated and untreated leaf samples break if folded in half with the fold line perpendicular to the lamina veins. If they are folded in half with the fold line parallel to the veins the untreated leaf breaks while the treated leaves do not. When touched the feeling can be described as slightly paper-like but more rigid and a bit more brittle.



20-06

On day 8 and 9 changes are noticed in the leaves stored at room temperature in a sealed bag. They start to show some signs of moulding starting with the leaf held over an open flame, followed by the leaf that was boiled. The untreated leaf does not show signs of moulding but does start to change colour towards a more yellow colour. On day 13 the untreated leaf sample has turned almost fully yellow and brown and the other two samples now show more black and white mould spots.

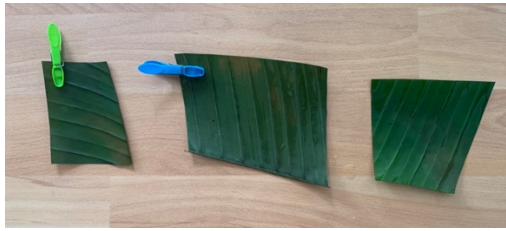


27-06



01-07

On day 10 the samples left in water also start to show some discolouration. The untreated leaf shows the most discolouration in the form of 'Stains' which are most visible on the backside of the leaf (abaxial). On day 13 the treated leaves also start to show some minor discolouration.



28-06



28-06



01-07



01-07

The leaves kept in the fridge stayed good for a longer amount of time. The pre-treated leaves started showing discolouration after 7 weeks and the untreated leaf after 8 weeks. The leaves in the freezer were still good enough to use after thawing after 4 months but will likely stay good for longer.

Conclusions

- If held over an open flame the leaf shows undesired discolouration. Because there is no noticeable difference in material properties between the leaf treated in boiling water or held over an open flame, boiling the leaf is more desirable since it retains the colour of leaf better, which is a consumer preference.
- Pre-treating leaves by applying heat to the leaf make the leaf less prone to breaking after drying out, especially in the direction parallel to the leaf.
- If stored in airtight bags at room temperature make sure the leaves are fully dry and well cleaned to prevent moulding.
- If stored at room temperature in an airtight environment leaves will turn yellow/brown after 8 days of storage.
- If stored in water leaves pre-treated with heat will stay green for 12 days and untreated leaves for 9 days.
- Leaves stored in the fridge stay green and fresh for about 8 weeks if they are untreated. Leaves can therefore better be stored in the fridge before pre-treatment and pre-treated when ready to be used.
- Storing in the freezer will keep the leaves good for the longest amount of time.

13.2 Packaging test 1

Start of test on 25-06-2024

Test set-up

To quickly get an idea of how a leaf will perform when it acts as a packaging rather than a plain leaf sample, a sphere and a rectangular cube were packaged with banana leaf. After this the packaged objects were monitored for changes. The sphere shape is packaged with a single layer leaf and the rectangular cube with a double layer of banana leaf.

Results

After two days the leaf around the sphere-shaped object was almost fully dried out, the part where the material is tied by the rubber band is not fully dried out while the rest is. The rectangular cube was not fully dried out over its whole surface. This is visible by the different colour the leaves have.



27-06

After day 3 both packages were fully dried out. On the picture it looks like the rectangular cube is not fully dried out, however it is actually dried out but shows a stain. When drying out the banana leaf also shrinks. Therefore the objects are slightly exposed after drying out while they were not at the time of packaging.



28-06



28-06

Conclusions

- When more layers are used it takes longer for the banana leaves to dry out.
- When banana leaves dry out they shrink which should be considered when using the material.

13.3 Pre-treatment tests

Start of test on 28-06-2024

Test set-up

This test was performed to see the effect of different pre-treatments on the characteristics of the material after drying out. The selected pre-treatments are based on methods mentioned on the internet to extend the shelf life of banana leaves. The pre-treatments are:

- Soaking leaves in 20°C water for 30 minutes
- Boiling leaves in 100°C water for 20 minutes
- Boiling leaves in 100°C water for 1 minute
- Heating leaves in a 80°C hot air oven for 3 minutes

For each treatment a sample was taken to examine the characteristics when dried. Next to this each material was used to package a small cube to see what the effect would be when the material is used as packaging material.



28-06



28-06

Samples from left to right: soaked in 20°C water, boiled in 100°C water for 20 min, boiled in 100°C water for 1 min, heated in 80°C oven for 3 min

Results

When packaging the first cube with the leaf soaked in 20°C water the leaf already breaks. After one day the leaf samples are almost dried out, however the leaves used to package the cube still contain moisture. On day two the leaf samples are fully dried out. From the packaged cubes the one packaged in the leaf that was soaked in 20°C water breaks further open because of the shrinkage occurring during drying. On day 3 all cubes are dried out as well.



29-06



30-06

When looking and examining the materials now the leaf soaked in water breaks in half when folded perpendicular to the veins, either to the back or front side, the other three samples show some tearing but still stay together. When folded parallel to the veins all samples show no signs of breakage. When stretching the leaf samples parallel to the veins by hand all samples stay together very well and do not break. When stretched perpendicular to the

veins all samples first slightly stretch and then break. The leaf treated in 20°C water clearly breaks the easiest, followed by the leaf boiled for one minute and then followed by the leaf boiled for 20 minutes. The leaf heated in the oven break the least easy but is close to the leaf boiled for 20 minutes. When looking at the packaged cubes, the one in the leaf heated in the oven stays the most flexible after drying out. The leaf boiled for 20 minutes is torn open and the leaf boiled for one minute shows some cracks but stays together. The leaf from the oven also stays the darkest green. Lastly it stands out that the leaf soaked in the 20°C water has the strongest smell.



20°C leaf (left) & 80°C leaf (right) after folding.



Packaged cubes after 3 days (01-07)

Conclusions

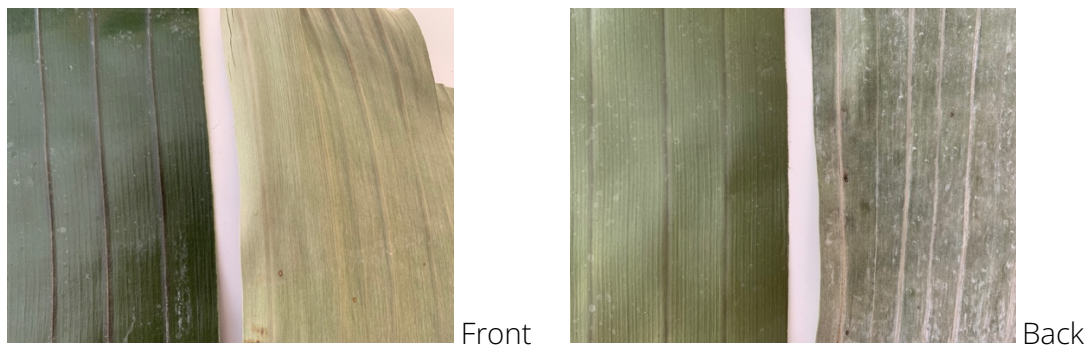
- Leaves need some form of heat treatment in order for the leaf to be flexible enough for folding before drying.
- When dried out the leaf heated in the 80°C oven for 3 minutes breaks and tears the least easy and stays the most flexible when used to package an object.
- The leaf heated in the 80°C oven stays the darkest green after drying.
- Boiling the leaf for 20 or 1 minutes is only preferred if the tensile strength perpendicular to the veins of the leaf blade needs to be larger.
- Due to shrinkage packaging can burst open if packaged before the material is dried out.

13.4 Folding and tension test

Start of test on 28-06-2024

Test set-up

For this test a fresh and a dried untreated leaf sample were taken to examine their properties when folding and stretching the material. The picture below shows the samples and their differences in colour when fresh compared to dried.



Results

First the samples were both folded in half towards the back and the front of the leaf both perpendicular and parallel to the veins. When folded perpendicular to the veins the fresh leaf sample shows the folding creases but stays together. The dried leaf fully breaks in half in this case.



When folded parallel to the veins both the leaves stay in tact but do show folding creases.



When stretched perpendicular to the veins it is quite hard to stretch the dried leaf to breakage by hand, while it is easier to stretch the fresh leaf to breakage. When stretching parallel it is much easier to break the leaf and it is still easier to break the fresh leaf than the dried leaf.

Conclusions

- Fresh leaves are better for folding, dried ones break easier when folded perpendicular to the veins while fresh ones only show creases and do not break.
- Dried leaves have better tensile strength in both directions than fresh leaves. Especially when stretched perpendicular to the veins the dried leaf is harder to break.

13.5 Boiling and layering tests

Start of test on 28-06-2024

Test set-up

In this test the influence of boiling the banana leaf before and after putting it into the desired shape was tested while also using multiple layers. In this case 20 leaf strips were boiled for 1 minute, then they were assembled into two groups of 1, 2, 3 and 4 layers of strips. Each of these were formed into a ring by attaching them with two pins. At this point there are 8 rings of which two with 1 layer, two with 2 layers, two with 3 layers and two with 4 layers. Of each amount of layers the rings were boiled again for one minute after they were put into a ring shape. Then they were put on a board to monitor and see the effects of drying on all samples.



Samples from left to right: 1, 2, 3, 4 layers. White pins are boiled once, golden clips are boiled a second time after putting them into shape.

Results

After one day the single and double layered rings are completely dried out. The triple layer ring that is boiled once before shaping is also almost dried out while the one that is boiled a second time after boiling still contains quite some moisture as well as both the rings with four layers.



29-06



29-06

After two days all samples are dried out fully except the four-layer sample that was boiled twice. After 3 days this sample was also fully dried out resulting in:



All shapes that were boiled after shaping them into a ring hold their original shape better than when only boiled once before shaping and the more layers are used the better they hold their shape. More layers also means slower drying. When stretching the rings they easily tear because of the punctures made by the clips. If you just stretch the strip at two sides perpendicular to the veins the samples that were boiled twice are harder to break than the samples that are boiled once.

Conclusions

- When boiled a second time after shaping the banana leaves hold their shape better.
- If punctured the leaf tears very very easily, so preferably do not puncture the leaf.
- When boiled a second time after shaping the banana leaf strips have higher tensile strength in the direction perpendicular to the veins than when boiled once before shaping.
- When more layers are used it takes longer for the leaves to dry and it holds the original shape better than when less layers are used.
- When drying a shape without something to hold it in shape the shape deforms when drying. For example, when drying around an object (packaged cubes in test 10.3) the leaves hold the shape they were put in before drying.

13.6 Shrinking test

Start of test on 01-07-2024

Test set-up

For this test an untreated leaf and a leaf that was boiled for 1 minute were measured when taken out of the fridge where they were stored. They were then placed under a few books that act as a weight to be dried. The books are used to let the leaves dry out as flat as possible in order to perform better measurements. After the leaves are dried out, they are measured again to see how much the material shrinks and if there is a difference between boiled and untreated leaves.

The two samples were cut to the same size before drying which is:

Top: 17,5 cm

Left: 24,5 cm

Right: 24 cm

Bottom: 19 cm

Results

After drying under the weight of the books for 5 days the leaves were still not dried out because the moisture cannot escape. Therefore, the leaves were placed between to wire mesh sheets to dry further. After two days of drying between the wire mesh the leaves were fully dried.



Left leaf is boiled, right leaf is untreated (both stored in the fridge).

After drying the leaves are:

Left leaf (boiled)

Top: 11 cm

Left: 24 cm

Right: 23,5 cm

Bottom: 15,5 cm

Right leaf (untreated)

Top: 12 cm

Left: 24 cm

Right: 23 cm

Bottom: 14 cm

In these cases, the shrinkage is about 2% on the left side and 2% (boiled) and 4% (untreated) on the right side of the leaf. On the top side the leaves shrink 37% (boiled) and 31% (untreated) and on the bottom 18% (boiled) and 26% (untreated).

Conclusions

- In the direction parallel to the veins the leaf does not shrink that much, only slightly.
- In the direction perpendicular to the nerves quite some shrinkage is noticeable.
- There is no clear evidence that the boiled or untreated leaf shrinks more or less. The shrinking likely depends on the moisture content and thickness of the leaf in certain places.

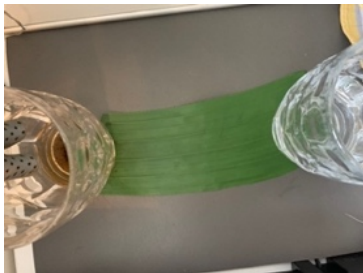
13.7 Drying tests

Start of test on 05-07-2024

Test set-up

This test is meant to explore different ways of drying the leaf in such a way that it dries without curling up. For this the samples are first cut into shape and boiled for 1 minute. Then they are dried and several ways of drying out are tried:

- Drying with a few weights stretching the leaf out
- Drying fully pressed under a weight (books)
- Drying between wire mesh
- Drying while stretched in the air
- Drying by ironing (forced drying) (under baking paper, not directly to the leaf)



Additionally a piece of banana leaf with the midrib still attached to it was dried between wire mesh to see what the effects are.

Results

After 2 days of drying, on the 7th of July all samples except the one drying under a weight are fully dried out. To speed up the drying process of the leaf sample pressed under a weight paper is added on either side of the leaf to absorb the moisture of the leaf while drying.



From left to right: few weights, wire mesh dried, stretched in the air, fully pressed under weight, ironed (two times)

The leaves used for this test are different leaves compared to the other tests, they are smaller (total leaf is 1 meter by 40 cm) and thinner. Therefore, they dry differently than the previous leaves. The leaf dried under two weights shows some markings of the weights, dried flat in some areas and wrinkled up in others. The leaf dried under wire mesh has crumpled quite a bit and shrunk a lot on the end that is attached to the midrib. The leaf dried by being stretched out in the air has by far the largest flat surface after drying and does show some crumpling in the middle of the leaf. The leaf pressed under a weight dried significantly better when paper was added to speed up the process however it took 10 days for the leaf to be fully dried out. After drying out this leaf its shape is almost the same as before drying and the leaf has by far the largest surface area. The leaves that were ironed dried out after approximately 2 minutes of ironing per leaf, they did still crumple a bit, but have the same properties as the other samples. When tried with a different leaf sample the crumpling was more or less eliminated. It is important that the leaf is not directly ironed but is protected by a sheet of baking paper with the temperature of an iron.

When the leaf is dried with the midrib it looks as follows.



As you can see the closer to the midrib the more crumpling there is. It also takes a longer amount of time for the leaf to dry out when the midrib is still attached because it contains more moisture. The midrib shrinks less in the direction perpendicular to the veins than the leaf blade. This prevents the midrib from drying out flat. The midrib also becomes really hard after drying. It does make for a sturdy base that keeps the leaf a bit more rigid.

Conclusions

- The thicker the leaf the flatter it stays during drying (less crumpling).
- By stretching a leaf out while drying it dries with a larger amount of flat surface.
- Adding a weight on top of the leaf while drying will retain the shape of the leaf very well, however it dries very slow, because moisture can escape less well.
- Drying the leaf between mesh wire will keep the leaf relatively flat but does not eliminate crumpling.
- Forced drying by ironing works the fastest to dry the leaf and keeps it flat. It does work best when there is a way for the moisture to escape and when the iron is left on the leaf until it is cooled.
- Drying with the midrib attached is undesired because it dries slow and the midrib shrinks differently than the leaf blade.

Test with cassava glue and drying with and without rack

05-09-2024

Test set-up

To see the effect of cassava glue on drying the leaf a test is performed where a sample is dried with and without the use of a drying rack. For both samples 3 layers of leaves are glued to each other and left to dry.

Results

As expected, the leaf drying without the rack curls up very much and does not stay flat. The leaf between the rack stays flat and only slightly deforms at the sides.



Conclusions

- To dry flat the sheets need to be dried between a drying rack. Also when using cassava glue.

13.8 Natural glue test

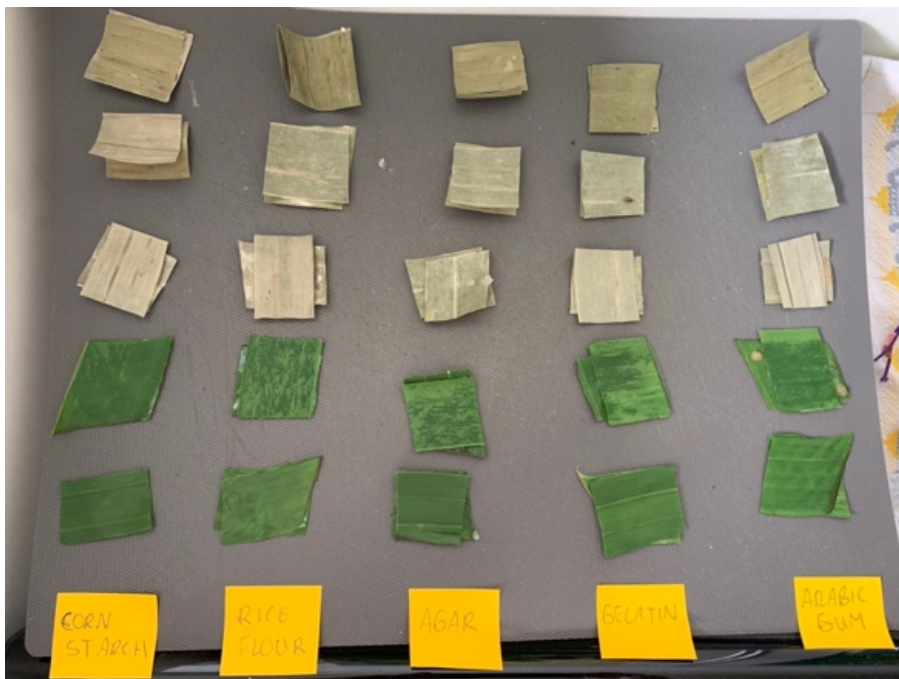
Start of test on 09-07-2024

Test set-up

This test is to compare several options for natural glues to be able to stick the banana leaves together in layers or attach them. For this test the following 5 glues were tested:

- Corn starch with water
- Rice flour with water
- Agar (red seaweed) with water
- Gelatin with water
- Arabic gum with water

Each type of glue is applied to 5 leaf samples of which 3 dried and 2 fresh. The samples are applied to each other in different directions and to different side to see if it has any influence on adhesive power.



Results

One day later the glue in all samples has dried. The agar did not work at all and the leaves are not stuck together. All the other samples stuck together but the leaves that were glue when already dry are relatively easy to take apart. The samples that were glued when not dried are harder to take apart and stay together quite well, they do curl up when drying. The arabic gum seems to work slightly better than the other ones.

Conclusions

- Agar does not work well and can be excluded
- Glueing leaves before drying works better than after drying
- More testing should be done with variations of natural glues. There are options that involve more ingredients or cooking time to improve the properties of the glue.

13.9 Glueing test 2

Start of test on 23-07-2024

Test set-up

Because the first test with natural glues was not very successful new types of glues should be tried out. To test if glue works at all some prototypes were made with glue spray. This worked out very well so therefore a test with a presumably more strong version of natural glue is done. For this recipe 500 ml of room temperature water is mixed with 100 grams of flour with a whisk. This is placed in a pan on a stove with the heat on medium. When the mixture starts to warm up 150 grams of sugar is added. Throughout the whole process you should not stop stirring. When the sugar is dissolved 1,5 tablespoons of vinegar are added and once this is stirred through a tablespoon of baking soda is added. The mixture will foam because of the reaction between the vinegar and baking soda. When the mixture starts thickening you can take it off the stove, stir until it is smooth and then let it cool. After that you can use it as glue. The glue is used to glue together dried and fresh leaf samples that were cooked for one minute. After glueing there are 6 dried samples and 5 fresh ones.

Recipe: <https://www.youtube.com/watch?v=p8ipSODdpuE>

Results

After drying both the dried and fresh leaf samples stick together very well. It is still possible for all the samples to peel the sides off each other, however some of them will rip. Overall all the fresh leaves are stuck together the best. Between the dried samples there are some differences. The thinner the leaves the harder they are to take apart and the thicker the easier.



Conclusions

- This glue recipe (see above) works well for this application. It sticks the leaves together and keeps them attached properly enough. It can also be taken apart, but only if wished to do so.
- The glue works on fresh and dried leaves, although it works slightly better on fresh leaves.
- More tests can be done by using this glue in prototypes

Test with different flour

05-08-2024

Test set-up

Because flour is not widely available in Ghana, but cassava flour is, a test needs to show if the natural glue also works with cassava flour or maybe with cassava starch or corn starch. First the same recipe as above is used but the flour is substituted by cassava flour, cassava starch or corn starch. After making the glue and letting it cool down three test samples are made where two leaf pieces are glued on top of each other. Once they are dried they are compared with each other.

Results

After drying all the leaf samples stick together very well. It is still possible for all the samples to take them off each other, but some are harder to unstick and rip. Overall, the sample where corn starch was used is the easiest to unstick and the ones where cassava flour and cassava starch are used stick together better and rip when trying to take apart.



Conclusions

- The glue recipe works less good with corn starch. This might be because of the starch but could also be because of the proportions of ingredients in the recipe.
- The glue recipe works well with cassava flour and cassava starch (tapioca starch). It sticks the leaves together and keeps them attached properly enough. It can also be taken apart, but only if wished to do so.
- When storing the glue in the fridge the one where cassava starch was used became thicker than the rest of the glues and binds more than the other ones, almost forming a more pudding like structure. Therefore, this recipe might work better if less cassava starch is used.
- Cassava flour is courser than starch, therefore the glue is less smooth and contains some lumps. This makes the glue look slightly less appealing but does not hinder the function.
- Both cassava flour glue and cassava starch glue work well and can be used. This is nice since these ingredients can be obtained easily in Ghana as opposed to normal flour. If there is time another test could be done with an altered cassava starch recipe, but it is not necessary.

Test with spray glue made with alcohol

05-08-2024

Test set-up

Because tests with spray glue showed different results than with the natural glue it would be interesting to see if the natural glue in spray form could have a different effect. For this the natural glue is mixed with rubbing alcohol in a spray bottle with a ratio of $\frac{3}{4}$ natural glue to $\frac{1}{4}$ rubbing alcohol. It is then sprayed on a sample and evaluated.

Results

After drying all the leaf sample sticks together very well. In adhesive power there is no noticeable difference between spraying or just applying the glue. The crumpling is also at about the same level in both the sprayed and non-sprayed sample.



Conclusions

- If you look at effectiveness of the glue and result after drying there is no benefit of spraying over just applying glue. Both work well and give about the same results.
- For convenience spraying is a good solution to increase speed in the production process. This depends on the availability of spray bottles and alcohol in Ghana.

Test with spray glue made with water

05-09-2024

Test set-up

Since alcohol can still be harmful to the environment the same test as above is done but the alcohol is substituted with water. A test is performed with two and 3 layers of leaves.

Results

After drying the leaves stick together well but only when enough glue is applied. It does dry a bit slower than with alcohol, but still provides a good sample. On the two layer sample less glue was applied resulting in a less strong bond and the 3 layer sample more glue, providing a better bond.



Conclusions

- If spray glue with water is used it is important that enough glue is used to provide a strong bond.
- Overall with this recipe the crumpling is less, which is not desired.
- The ability to use the glue as spray glue also depends on how smooth the glue is. It might be less smooth with cassava flour since it is more course. A test with cassava starch can be done to see the effects.

Appendix 14

Ideation & conceptualisation

Below firstly the creative sessions that are conducted with IDE students are documented. Next to this the process of clustering and categorizing the ideas is documented.

14.1 Creative sessions

Two creative sessions were conducted with IDE students. The first session had 3 participants which included people who had experience with working in low to middle income countries. One of these people has done a project in Ghana specifically. The second session had 2 participants with no experience of working in low to middle income countries. The sessions consisted of the following elements:

1. Introduction on the topic consisting of a summary of the research and the chosen design focus.
2. Question round about the problem as given.
3. Short purge where first ideas can be written down.
4. Looking at the schedule of the day.
5. Five flower association with different words from the problem as given.
6. Restating the problem into the problem as perceived by the participants.
7. Short purge where more ideas can be written down.
8. How to's with the criteria as starting point.
9. Brainstorming on post-its.
10. Break.
11. An energizer to get the participants back into the process.
12. Clustering the ideas by the participants.
13. Hits and Dots. Participants can choose several promising and exciting ideas.
14. Rapid prototyping one of the chosen ideas with a banana leaf and some additional tools.
15. Presenting the solution that has been prototyped and sharing their perspective on the problem.

Creative session 1





Creative session 2



Appendix 15

Prototyping

The ideas from the ideation phase were categorized and the ones that have potential were selected for prototyping to see if they are actually feasible.

15.1 Folding containers

12-07-2024

Prototype

Here the idea of using folding techniques to create containers for retail in the supermarket is explored. Several folding techniques for bowls and open boxes are tried out. The leaves are first boiled for one minute, then they are dried and folder into the right shape. Some shapes are held together by a weight or clips during drying to ensure they dry in the right shape.



Conclusions

- After drying some containers are quite deformed compared to their shape they were folded in even though clips and weights are used. Therefore trying to dry them in a mould would be useful to see if it creates the desired results.
- For some designs glueing certain areas of the container together would be beneficial, this should also be tried.
- In general some folding techniques show more potential since they are easier and quicker to fold and have potential for including a tool to speed up the production process.

15.2 Folding containers with drying mould

17-07-2024

Prototype

Following out of the previous test, 4 containers suitable for drying in a mould were selected. To create a quick mould paper is used. Two models of the same container as the leaf are folded from a slightly larger and smaller piece of paper to form an inside and outside mould. Before folding the leaves are boiled for one minute to make them more flexible and they are dried with a towel afterwards.



After four days of drying the moulds with leaves they are quite crumpled and did not retain the shape they were originally folded in.

Conclusions

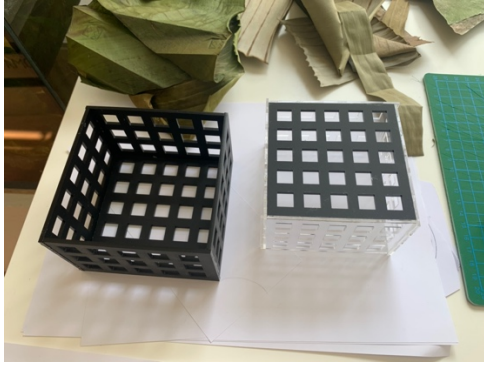
- To dry in the shape the leaves are folded in a rigid mould is necessary.
- For the 'pyramid shaped' container more than 2 mould pieces would be necessary.
The resources and effort versus the effectiveness of the solution compared to a box shaped container is not worth it.

Prototype with rigid moulds

23-07-2024

Prototype

Because the paper moulds crumple with the leaf while drying, rigid moulds are necessary to dry the folded leaves in. For this a mould made out of PMMA was made with holes to allow for fast drying. A larger and slightly smaller container were made where the folded leaf can dry in between just like with the paper. Again the leaves are boiled for one minute and then folded in between the two mould halves.



When drying in the mould the rigid mould it retains its shape very well and gives a more desired result than in the paper mould, however it does crack in some point because it has less room to shrink during drying.



Conclusions

- Drying in a rigid mould retains the shape of the container very well.
- Ventilation holes in the mould make for quick drying that takes about the same amount of time as drying without any additions.
- Because the material shrinks it can rip when drying in the mould. Therefore an additional smaller inside mould can be made. The container can be folded in the size of the original inside mould but the new, smaller inside mould can be used for drying to prevent ripping.
- Another way to test if ripping can be prevented is to change the vein direction when folding and putting the container in the drying mould.
- To retain the shape even better a test can be done where glue is applied in certain area's to keep the corners together for example.

Prototype with rigid mould, glue and a smaller inside mould

26-07-2024

Prototype

Compared to the previous prototype a larger leaf sample is taken to have higher upstanding sides. Additionally, a smaller inside mould for drying is used to account for the shrinkage of the material that occurs during drying. For the smaller inside mould card decks are used to

allow for quick iteration. Lastly glue is applied when folding to see if this helps retain the shape of the leaf better.



To speed up the drying of the container it was placed in the sun inside the mould. While it sped up the drying process it also made a block pattern appear on the container. In the places where the sun could directly reach the leaf the leaf turned more yellow/brown and in the places where the sun did not reach the container because of the PMMA the container stayed greener.

Conclusions

- Using a leaf sample of appropriate size makes for a neater container.
- Because of the combination of using glue, a different type of leaf and an inner mould that allows for less ventilation the container dries out way less quickly.
- Drying in the sun makes the leaf turn yellow/brownish while drying when not directly in contact with the sun keeps the leaf greener.
- The combination of using glue and a smaller inside mould makes the leaf retain its shape more.
- A model with higher reaching sides could contain the tomatoes better, this could be tried out.

15.3 Hammock

16-07-2024

Prototype

This prototype is to test the feasibility of using banana leaves as a packaging for transport by using them as a vessel to hang tomatoes in. For this prototype 4 leaf halves are boiled for one minute and cut into the desired length. They are then attached to a frame that fits within a tomato crate. This creates a suspended area where tomatoes can be placed in. The leaves are put in place prior to drying and will dry out during use. For a small test some items are placed into the prototype to test if it will last when drying.



After 4 days of drying the leaves were dried out and somewhere in the process some of the weights broke through the leaves while others stayed in place. After taking down the hammock the leaves kept their shape and also showed some indents of the weights.



Conclusions

- The hammock idea is a hard one to realize in the context. On top of this it broke down and could not take the weight. Therefore this idea is not suitable.
- By drying the leaves in a maintained position they retain their shape. Tests with making indents can be done to see if this is feasible.

15.4 Ventilation tube

22-07-2024

Prototype

This idea is meant to function as a ventilation tube in the crate to allow for more cooling of the produce. To prototype it two boiled leaves are overlapped and wrapped around a cardboard tube and secured with rubber bands. The tube is punctured numerous times to enable quicker drying of the leaves. After wrapping the leaves are also punctured to ensure quicker drying and more ventilation in the end.



When dried out the material shrinks. In this case it shrunk around the tube making it very hard to remove the the leaf from the cardboard. It had to be unrolled in order to get it off which separated the two leaf pieces. After unrolling the leaves are also not sturdy and collapse easily.



Conclusions

- To get the tube from the mould it should be dried inside a tube rather than around it.
- To keep the leaves together they can be glued to each other before drying.

Drying inside a tube

26-07-2024

Prototype

In the previous prototype it was hard to remove the leaves from the tube because of the shrinkage during drying, therefore the leaves are now dried inside a tube. Next to this glue is applied to keep the two leaves together while drying and after. The leaves are rolled up like in the previous prototype and rolled inside a tube for drying.



After drying out the tube stays together and is easily removable from the tube, it even slides out on its own. When trimming the sides it can stand up on its own and has quite some strength when pressing on it from the top. From the side it is fairly easy to quash it.

Conclusions

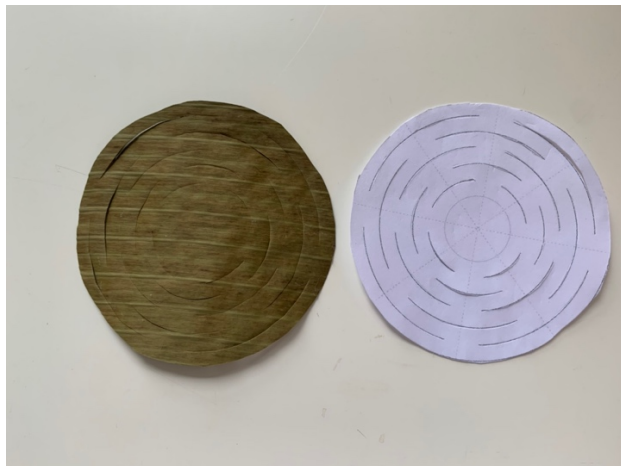
- The tube it will likely be crushed from the sides if it is placed inside a crate with tomatoes as it is now. Since there are other more promising options this concept will be disregarded for now.
- As a tube it can hold some weight on top and could form a support for other things.

15.5 Cutting pattern

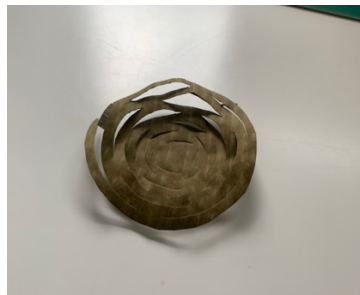
22-07-2024

Prototype

By applying a specific cutting pattern to a sheet of paper or in this case a banana leaf, a 3d object or net like bag can be created. This could be used as a packaging for retail that allows for ventilation or a packaging for transport to divide the amount of tomatoes in the crate into smaller bundles. To prevent ripping of the leaf it is necessary for the leaf sheet to consist of multiple layers of leaf placed over each other with the vein directions perpendicular to each other. Then the different leaves are glued to each other. In this case two leaf samples were boiled for one minute, dried, cut to the desired shape and glued together. After drying of the glue the cutting pattern was applied to the sheet.



After the cutting it was possible to carefully transform the sheet into a 3d net-like shape. When doing so carefully it could be formed into bowl but after stretching it some more it ripped.



Conclusions

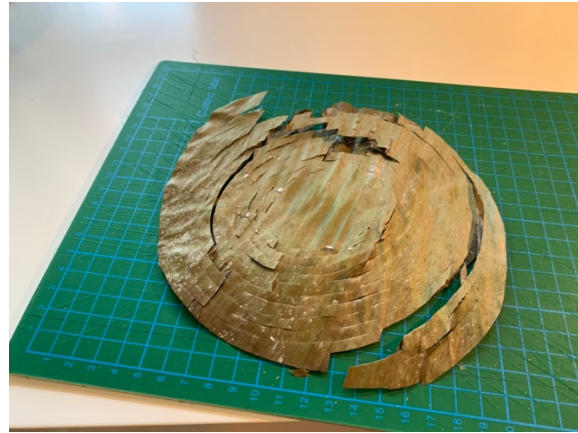
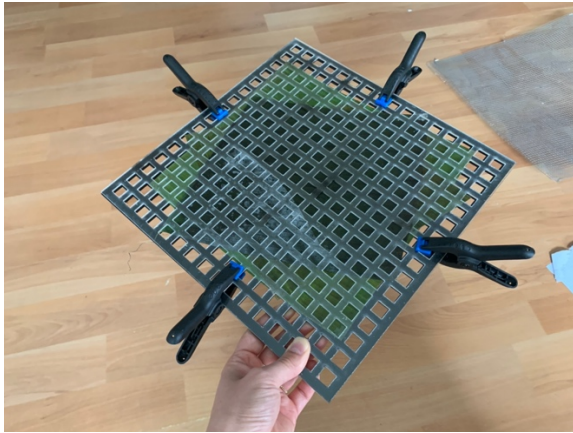
- Sticking together multiple layers of leaves with the veins perpendicular to each other makes cutting the leaf possible.
- Maybe more layers of leaves and placing them in more different directions would work better, this could be tested.
- Because the sample is quite small it becomes a very small bowl or net. To better investigate the potential of this idea a larger sample would be needed.

Larger prototype with more layers

26-07-2024

Prototype

As an iteration on the last prototype a sheet with 3 layers of banana leaves is produced to see if this makes for a stronger sheet that is even less easy to rip. The sheet is larger as well to see if a bigger bag or bowl can be made.



After drying the stencil is placed over the sheet and the cutting pattern is applied to the leaf structure. The cutting itself goes well but when the stencil is removed some parts of the leaf come loose and rip. It is very hard to fold out the shape into a 3d one and rips more when tried.

Conclusions

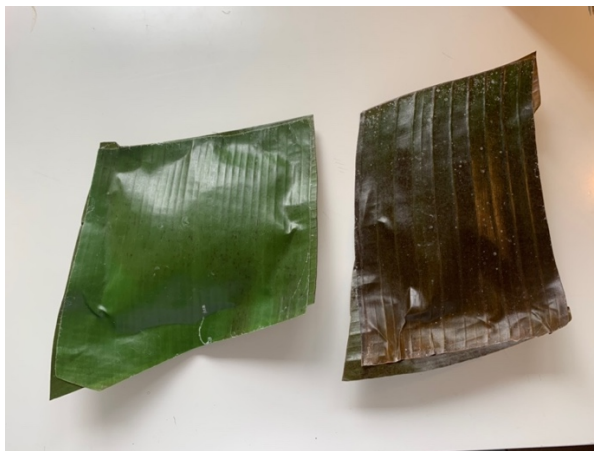
- The realization of this concept is very hard since there is a big risk on ripping the structure unless you do it perfectly.
- Using 3 layers of leaves made the sheet thicker and less flexible which is undesirable for this concept. It made the prototype rip and unable to transform into a 3d shape.
- For now there are other prototypes which are more promising and this one is for now deemed not feasible to realize within the project.

15.6 Cushion with filling

22-07-2024

Prototype

For the purpose of reducing damage cushioning can be used in the transport crates. To try this a pillow like object is made from the leaves. One fresh boiled leaf sample is placed in a mould. Then this is filled with leftover dried leaf scraps until the desired amount is reached. After this glue is applied to the edges of another fresh boiled leaf sample and that is placed on the other leaf sample filled with dried leaf scraps. When stuck together this forms a kind of pillow like object. When ready it is placed in a rack to dry. It could also be used right away. In this case two prototypes are made with different kinds of leaves to see the difference.



After drying the pillows are quite firm and form a good padding material in the middle where the leaf scraps are located. The glued edges have crumpled and overall the pillows also shrunk.



Conclusions

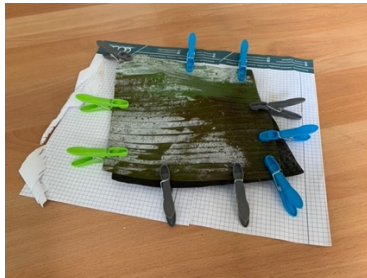
- This prototype uses scrap material of the leaves, making it possible to use a higher percentage of material and eliminates waste material.
- The solution forms a good padding, but is on the thick side so an iteration with less material can be made. It does look somewhat messy.
- This prototype is quite small so it would be interesting to see what a smaller version would look and feel like.

Larger prototype with less filling

26-07-2024

Prototype

This prototype is made with less scrap material to make the pillow slightly less thick. Next to this the prototype is made with larger leaf samples to see the difference between the previous prototype and this one. The previous prototype was glued together with spray glue to see if it would work at all. This prototype is fabricated with the natural glue recipe from appendix 13.9. Because this is more liquid when applied it needed to be held in place by clips to dry as is visible below.



After drying some of the edges came loose, leaving holes at the sides. Next to this the pillow did not dry out flat.

Conclusions

- When using the natural glue for making the pillow the result is less neat and sticking the edges together is harder.
- Overall, the design is quite hard to make compared to other prototypes that are meant for the same purpose. Next to this making a prototype that has a larger surface is very hard so lots of small pillows would be necessary. The combination of all of this makes that it is fair to conclude that this concept is not suitable enough for the project brief and design goal.

15.7 Layering, glueing & drying

22-07-2024

Prototype

The aim is to make a sheet of banana leaf where two sheets are glued to each other with the nerves of the leaves perpendicular to each other to improve strength. These stronger sheets can function as a layer between tomatoes in transport crates to provide cushioning to absorb shocks and vibration and even out weight of the pressure of tomatoes on top of each other. Glueing can be done before or after drying. If the sheets are glued before drying the different percentage of shrinkage in different directions might influence how the leaf dries out. If the sheets are glued after drying it might be harder since they dried out slightly differently and sticking them together is harder. This will be explored in this test. For the test two times two leaf sheets were glued to each other with glue spray before drying. Next to this, 4 leaf sheets are dried flat between wire mesh to be glued after drying. In this case the shrinkage in different directions is taken into account to ensure the right size when glueing. For this experiment glue spray is used since it is a strong adhesive that will definitely work as opposed to some natural glues.



Leaves glued before drying (left) and leaves glued after drying (right).

The leaves that were glued before drying crumpled up but stayed together. They form a rigid mat that has some thickness to it. The leaves that were first dried and then glued also stay together well, they form a flatter but still quite rigid mat. Both rip way less easily than a single dried leaf.

Conclusions

- Joining leaves together with their veins perpendicular to each other makes the leaves less easy to rip and stronger in both directions when tugging on them.
- With the spray glue the strength of adhesion does not differ when the glue is applied before or after the leaves are dried. With other glues this might be different so it should be tested.

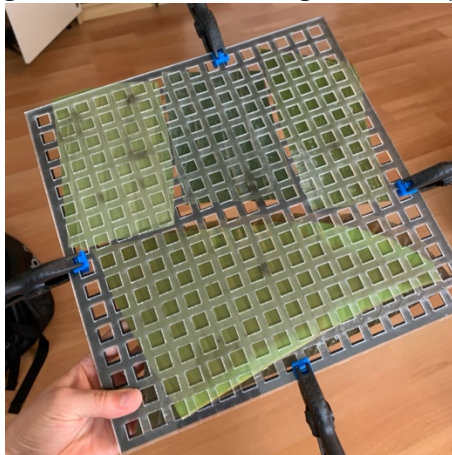
- A different way of drying could be explored to see if a leaf can be dried even flatter. This could be useful for glueing things together when they are dried to create an as large as possible area that touches each other.
- If leaves are glued before drying, they can crumple up into a sort of padding material, this could have potential for absorbing shocks and vibrations. More tests should be done if this works with other glues and other leaf types.

Drying between PMMA plates

23-07-2024

Prototype

This prototype was made to see if leaves samples can be dried even flatter than between wire mesh. Therefore a more rigid material is taken, in this case PMMA, and laser cut in the desired shape. The sheet contains square holes to enable faster drying and can be secured with clips when leaves are placed in between. Both single layer leaf samples and double layer leaf samples that are glued together are dried. The leaf sample showing below was glued with the natural glue from appendix 13.9.



Overall, the leaf dries flatter but does show some crumpling due to the shrinkage of the leaf when drying.

Conclusions

- Drying leaves pressed between two rigid plates with holes allows for creating very flat single and double layer leaf sheets.
- Glueing and drying leaf samples with the natural glue from appendix 13.9 gives a good result. The leaves are stuck together well enough when the glue dries.

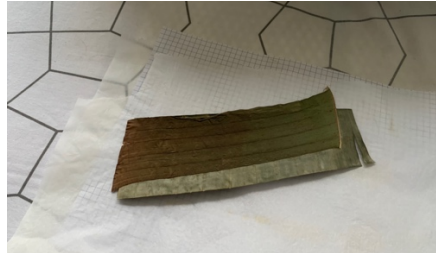
Drying under an iron

23-07-2024

Prototype

To see if leaves can be dried even flatter a test is done with drying under an iron. For this, natural glue was applied to two boiled leaf samples, they were placed over each other with

the veins perpendicular to each other, placed on a sheet of paper and covered with baking paper. Then they were ironed for about 5 minutes and left to dry with the iron still on them as a weight. As is visible below the ironed leaves stay very flat. The adhesion is also good. After drying some more the leaf does curl a bit.



Conclusions

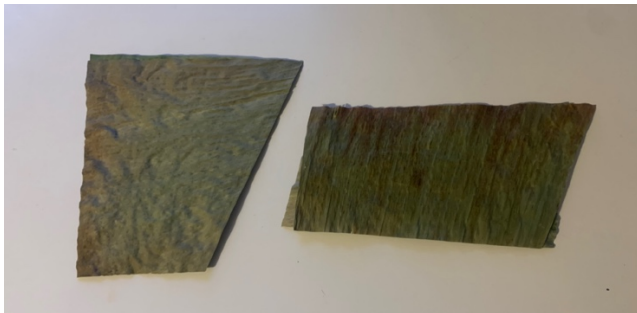
- Ironing leaves and leaving them to cool down under a weight allows for very flat drying without almost any crumpling.
- After fully drying out after ironing the leaf it can still curl a tiny bit.

Glueing before and after drying with natural adhesives

23-07-2024

Prototype

For this the first test above was tried out with natural glue from appendix 13.9. Two leaves were glued together and then dried and two leaves were dried and then glued together. All were dried between wire mesh.



Leaves glued before drying (left) and leaves glued after drying (right).

Both leaves show crumpling. The one that was glued before drying shows more crumpling but less than the one in the previous test that was glued using spray glue.

Conclusions

- Between the leaves that were glued before or after drying there is no noticeable difference in the adhesive strength of the glue.
- The leaves glued before drying with adhesive spray show more crumpling than with the natural glue. This could be because of the leaf type. Therefore glueing different leaves with the natural glue should be explored.

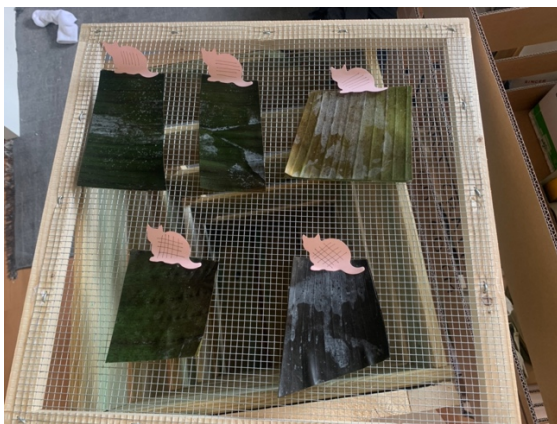
- To see if more crumpling can occur, since this could help with shock absorbing, different glue patterns can be tested.

Different glueing patterns

28-07-2024

Prototype

To see if different types of crumpling occurs in leaves that are glued before drying different types of glueing patterns are tried. In previous tests glue was applied to the full surface of the leaves. In this test stripe patterns are tested. They are either applied perpendicular, parallel or diagonally to the leaf veins as shown below. The pattern is shown on the post-its.



Overall all leaf samples show crumpling but in the ones on the top row it stands out that one side is more crumpled up than the other. The crumpling also occurs in bigger bulges that eventually tear more easily when pressure is put on the sheet. In the samples on the bottom row crumpling is more even on both sides and slightly smaller. The flexibility is better, and the crumples do not tear but bounce back. The likely reason for this is the fact that in the sample on the top row glue was only applied to one side of the leaf while in the bottom row the glue was applied to two sides because of the glue patterns with overlapping lines.

Conclusions

- Overall glue patterns do not seem to have a great advantage or better outcome over applying glue to the entire surface of the leaf. Therefore, applying a glue pattern seems like an unnecessary hassle.
- Applying glue to both sides of the leaf surface that are placed upon each other seems like it would create more even crumpling. This could also be the case because more glue is applied in the patterns above that were applied to two sides which amounts to a higher amount of glue. A test could bring more clarity in this.
- When crumpling occurs in bigger bulges it tears more easily when dried and bounces back less easily. Therefore, smaller bulges are preferable.
- To make stronger thicker sheets a structure with more layers could be tested. It would be interesting to see what effect this has on the crumpling as well.

Testing with more layers

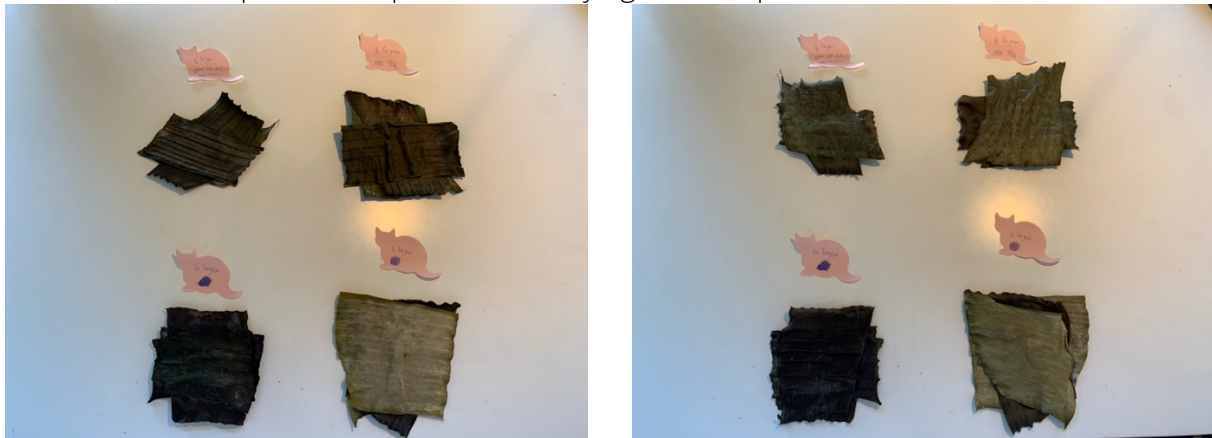
30-07-2024

Prototype

To see what happens with the crumpling and the strength of the sheet a test is done with multiple layers. The following samples are fabricated:

- 3 layers of leaves where glue is applied to the full surface on two sides (double layer of glue)
- 3 layers of leaves where glue is applied in a diagonal stripe pattern on one side
- 4 layers of leaves where glue is applied to the full surface on one side
- 3 layers of leaves where glue is applied to the full surface on one side

The first thing that stands out is that the sample with 3 layers of leaves where glue is applied to the full surface on two sides (thicker layer of glue) take a significant longer amount of time to dry, even longer than the one with 4 layers of glue. The one with 3 layers and double layer of glue is also the one that dries with the least amount of crumpling and is attached the best, it even rips in some places when trying to take apart.



The sample of 3 layers of leaves where glue is applied in a diagonal stripe pattern on one side shows the largest bulges. As stated previously this also makes that the sample breaks more easily and bounces back less easily. The sample with 4 layers of leaves where glue is applied to the full surface on one side is the stiffest sample after drying. It is the hardest to bend out of the 4 and also does not show very much crumpling but still some. Because of this the sample bounce back only slightly when being pressed upon. The sample with 3 layers of leaves where glue is applied to the full surface on one side shows by far the most crumpling and bounces back the most when pressed upon.

Conclusions

- When more glue is used the adhesive strength is better and the sample dries with less crumpling. For the current solution this is not the most desired, but it makes for a quite strong sample that can withstand great tensile strength.
- A glue pattern with more layers still makes for larger bulges that break easier and bounce back less easily.

- 4 layers makes for a stiffer, stronger sample that stays together very well, but seems to have less damping effect than the sample with 3 layers of leaves where glue is applied to the full surface on one side.
- The sample with 3 layers of leaves where glue is applied to the full surface on one side has the most crumpling and therefore seems to have the most damping effect.
- It would be interesting to see what would happen when layers are glued together after drying and have two similar samples where one of the two has more glue applied to it than the other. This can finally conclude the effect of more or less glue.
- The prototype where leaves were glued before drying, using spray adhesive shows by far the most crumpling. To see if this can be achieved with the natural glue a test should be done with spray adhesive made of the natural glue. For this rubbing alcohol can be mixed with the natural glue. It can then be placed in a spray bottle to use and see the results.

Thick and thin layer of glue + glue pattern along veins

05-08-2024

Prototype

To see the effect of the amount of glue that is used two samples are made. One with two layers and a thick layer of glue and one with two layers and a thin layer of glue. Next to this one more glue pattern is tried. In the previous test where a crossed glue pattern was tested the glue was applied perpendicular to the veins of the leaf. Applying glue parallel to the veins could give a different effect. Here glue is applied in thin stripes along the veins of both sides that are stuck together.



Conclusions

- A thick layer of glue sticks the layers together more effectively and leaves a sample that is harder to take apart. It also crumples less, which in the end results in less air pockets on the leaf. A thin layer of glue results in more crumpling and air pockets and also stays together well. It is easier to take apart but still strong enough for the application. Therefore, using a thinner layer of glue is better.
- A thinner layer of glue dries faster, so it is a good option to speed up production time as well.

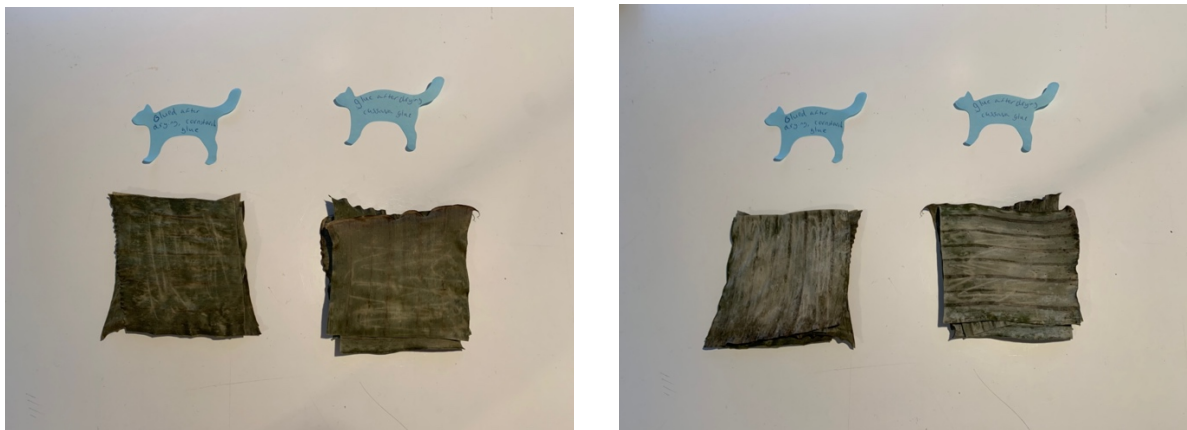
- Glueing a crossed pattern along the veins instead of perpendicular to them works way better. A very nice wavy crumpling pattern develops during drying. It is a very good option. Applying glue over the whole surface versus in a cross pattern does give slightly different results but does both result in a crumpled sample that bounces back when pressed upon. It feel like they could both absorb shocks well.

Glueing after drying

05-08-2024

Prototype

To see if it would be feasible to glue the leaves together after drying a test is performed. Since leaves crumple slightly more if dried plainly on their own this would be an interesting test to see if a sample with more damping effect could be created. For this test two leaves are dried between wire mesh, allowing for more room for crumpling. These form the inner layer. On the outside two flatter leaves sample will be glued. These are drying between the PMMA. This concept goes a bit more towards the corrugated fiber board example.



Conclusions

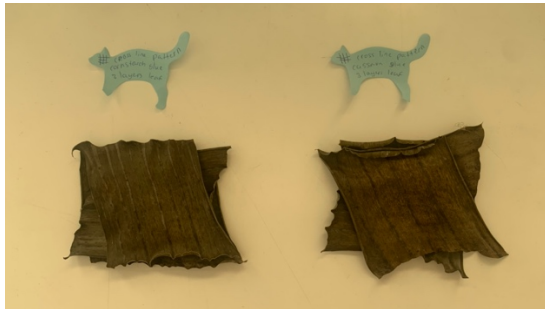
- Glueing the pieces together after drying is harder since they have their own shape and are not flexible anymore. This means less surface area is glued together. Which in the end also means the pieces stick together less well than when glued before drying.
- The end-result is a nice damping material that bounces back and could be very effective. However, if pressed upon a few times the different layers kind of separate and come apart.
- Overall, this concept would not be suitable since the piece comes apart to easily.

Crossed glue pattern along veins with 3 layers

08-08-2024

Prototype

Since the crossed glue pattern along the veins of the leaf was a fairly successful concept it is tried again. This time with more layers of leaves. 3 layers of leaves are put on top of each other with a crossed glue pattern in between, they are then dried between wire mesh. The sample is created twice, both with a different glue. One with cassava flour glue and one with cassava starch glue (left one on the picture but wrong text: cornstarch should be cassava starch).



Conclusions

- Both cassava glue and cassava starch glue work well for this application and stick together well.
- The crumpling of the samples is good and the damping as well, it bounces back when pressed upon. It does however show little difference in result when compared to a sample where a thin layer of glue is applied over the full surface of the leaves. Since applying glue in a striped pattern takes more effort and possibly more necessary tools which cost money this is not desirable over simply applying a thin layer of glue. Therefore, the stripe glue pattern is disregarded.

15.8 Mould with indents

23-07-2024

Prototype

Here is tested if the banana leaf can be dried in such a way that it forms a sheet with indents for the tomatoes. This is something that is sometimes already done for fruits like apples to have them stay in place during transport, but then it is usually made from plastic or cardboard. To test if this is possible with leaves a mould out of pmma is made with 9 holes. These holes are the mould to form the indents. By placing and securing a fresh boiled leaf over the holes and placing a weight in them the leaf will be dried.



After drying and taking out the marbles the indents are visible in the leaf. The biggest dent is the one in the middle, which also had the biggest marble as a weight. The one with 5 small marbles has the smallest indent. The leaf also shrunk quite a bit preventing some indents from forming.



Conclusions

- A larger leaf should be used to test without the leaf being shrunk so far that it affects the indents. Next to this the leaf can be placed a little more loose in the mould to allow for more room in the leaf to form indents while drying.
- The leaf is still quite fragile so to make it stronger two leaves can be used with the veins perpendicular to each other.
- The indents could be bigger. This can be achieved by have more weight in the mould indents which will also increase the dent size more.

Prototype with two leaves and more weight

26-07-2024

Prototype

For this prototype two leaves are used that are placed on the mould with the veins perpendicular to each other. In this case small glasses filled with marbles are used to create more even and hopefully larger indents. By using two leaves the idea is that the prototype is stronger and rips less easily.



Using two leaves makes the prototype stronger but also harder to shape since more layers are present. The glasses allow for more even indents but are hard to make larger since it needs quite a lot of weight to have that effect. During the process of drying a book was placed on top to add more weight. The book rested mainly on the three middle glasses which is visible in the size of the indents.

Conclusions

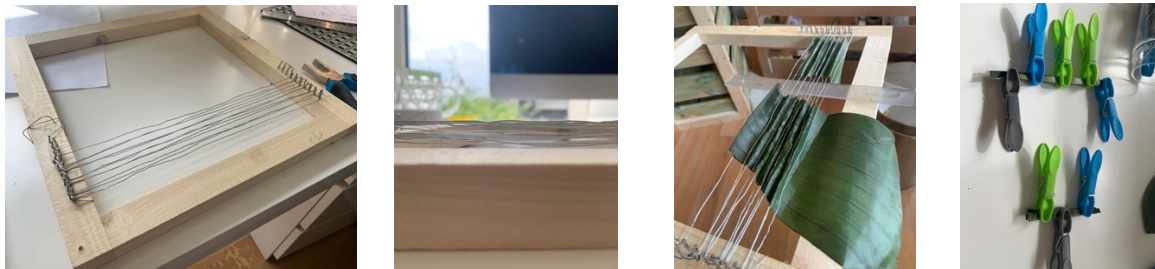
- To make the appropriate size indents a greater amount of weight or a press construction is necessary. In this case it would be logical to discard the idea of using individual weights for every indent since this is a bit of a hassle. The only option to realize this idea would be a sheet press with the indents in it.
- Using two leaves instead of one makes the prototype feel a lot more sturdy than using one leaf and does make for a sheet that keeps its shape very well.

15.9 Corrugated fibre board

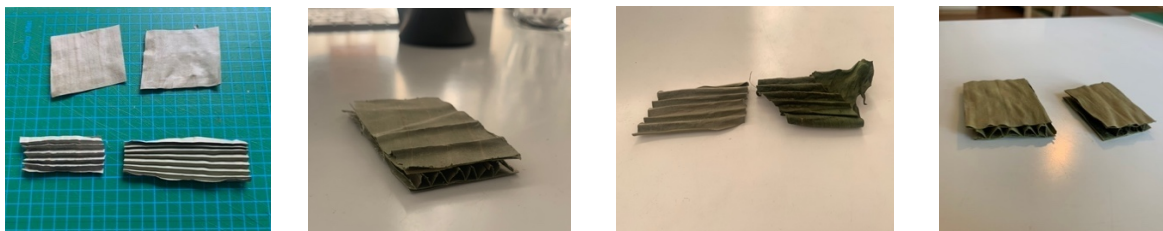
23-07-2024

Prototype

To help with cushioning and shock protection during transport a corrugated fibre board (cfb) sheet structure made out of banana leaf could work. For this two flat leaf sheets and a serrated leaf sample are stuck together. Therefore all sheets first need to be boiled and dried individually before being stuck together. The flat leaf sheets are dried between drying racks and to create the serrated leaves the methods below are used. In one case the leaves are folded and secured, in the other one they are folded around metal wire that is stretched around nails in a wooden frame.



Two flat leaf samples are stuck together and cut into shape. This leaves two double layer leaf sheets between which the serrated leaf sheet can be placed and glued. This is then left to dry. This is done for both the manners in which the serrated leaf is dried (folded and placed between wire).



From left to right: 1. Serrated sheets that were folded, 2. Cfb sheet with folded leaf, 3. Serrated sheets placed between wire, 4. Cfb sheet with wire leaf

The serrated leaf that is folded and secured has sharper folds than the one placed between the metal wire. This means that the one dried between wire has a slightly larger area that is glued to the leaf sheets. This could mean it sticks better. When feeling the samples the ones that were fabricated with the serrated leaf dried between wires, which has less sharp folds and more glueable surface, feels like it bounces back more. The one that was dried by folding initially sturdier but when pressed together is crushed more easily than the sample that was dried between wires.

Conclusions

- The prototypes of corrugated fiber board feel sturdy, rigid and like they could function as shock and vibration absorbing material.

- When fabricating the corrugated fiber board sheet a sharp folded serrated sheet is less desirable since it has less glueing surface to which it can be attached to the flat sheets. It also breaks more easily. Therefore a more wavy structure is desired, like when folding the leaf around wires for example.
- The current method of drying leaves between wires works but is very time consuming. For this a better, quicker method needs to be developed to be feasible for the Ghanaian farmers.

Water test with prototypes

30-07-2024

Prototype

When sheets of leaves are used for transport, it is likely that some tomatoes will still be damaged and release liquids. This will leak on the leaves and might influence their structure. Therefore, a small test with water is done to quickly analyse the effects. This is done for both a corrugated fiberboard structure as well as a leaf sheet that had been fabricated by sticking two leaves together with natural glue from appendix 13.9 since these are the most promising options at the moment. Both samples are held under a faucet for about 15 seconds and then placed directly in a rack to dry.



Glued sheet structure (left), Corrugated fiberboard sample (right)

During the time the samples are held under the faucet the leaves do not take up any moisture. After this there is still some water on the samples when they are placed in the rack. Initially they seem unaffected but after 5 minutes the leaves did take up some of the moisture on the sides. The corrugated fiberboard sample then starts to dissemble because the glue comes loose. The glued sheet sample however stays together but does curl up a bit. After drying again the glue also dries and the sheets attach to each other again.

Conclusions

- When the leaves get wet after drying, they are water repellent but do take up some water.
- The natural glue is somewhat soluble in water and part can come loose if there is too much moisture that can get to the glued surface. Then again if it dries the glue attaches again.

- The corrugated fiberboard structure comes apart quite easily since the glued surface of the serrated sheet is very small. Once that part comes loose it falls apart. Therefore, the glued sheet structure is more reliable.
- The glued sheet structure does take up some water but stays together since it is harder for moisture to reach the center parts of the sample. For the expected amount of moisture that will come from the tomatoes this seems acceptable.

15.10 Braided mat

23-07-2024

Prototype

To improve strength of the leaf they can also be braided instead just glued. This could function as separation of layers tomatoes to divide the weight of the layers tomatoes above and could help with shock and vibration absorption. This is tested with dried and fresh leaves that were first boiled. For this the leaf is ripped into strips either before or after drying and then braided into a mat structure. Glue is applied to secure the strips and make sure they don't fall apart when used. First a mat was braided with fresh leaves and left to dry without applying glue.



Without glueing the mat shrinks a lot and loses structure. Therefore, a mat with glue is made from dried strips as well as fresh strips after which it is dried.



Leaves glued before drying (left) and leaves glued after drying (right).

Both braided mats stay together very well and form a strong mat. Because of the shrinkage during drying the mat that is glued before drying shows holes after drying out.

Conclusions

- Braiding mats by hand is a quite time consuming activity, this should be taken into account when assessing feasibility of the design for the farmers in Ghana. A tool to speed up the process would be crucial. The leaves are easier to braid when still fresh in comparison to dried ones.

- Braiding strips with the vein direction perpendicular to each other allows for a stronger structure that does not rip easily. Especially the mat that is glued after drying has a strong, rigid structure.
- The holes in the mat that was glued before drying could allow for ventilation.
- A single layer mat would likely not help a lot with shock and vibration absorption but would work to divide weight.

Appendix 16

Post-harvest loss validation

To assess the effectiveness of the final design a test is done on the qualitative and quantitative post-harvest loss that occurs during transport with the use of the design. First the validation plan is explained and afterwards the results are discussed.

16.1 Validation plan

To validate the effectiveness of the final design in reducing post-harvest losses the test needs to resemble the real context of use as much as possible. The test will be done with tomatoes placed in a wooden crate together with the prototypes. The crate is then placed on a cargo bike and driven around after which the quantitative and qualitative loss of tomatoes is measured.

Method

In Ghana most often a medium sized crate of 70x70x70 cm is used for transport of tomatoes. For the test a wooden crate is created which has the same height of 70cm but a width and length of 35cm. This means the test crate contains a quarter of the amount of tomatoes that a medium sized crate in Ghana would contain. The choice for this option is that testing with a full medium sized crate would require a large amount of tomatoes which costs a lot and would also waste more tomatoes. The height of the crate is kept the same to simulate the same amount of compression from the layers of tomatoes on top on the bottom layers. The tomatoes that are used are ripe, undamaged tomatoes without stalks, like the tomatoes that are transported in Ghana. They are ordered from <https://groentebroer.nl/> and delivered at home, meaning they have already been transported before the transport test. Therefore they will be checked upon arrival and only firm, healthy looking, undamaged vegetables will be used for the test.

The prototypes used for the test are created as how the design is meant to be created in the real context. From different types of banana leaves 5 sheets are made. Each sheet contains 3 layers of leaves placed over each other in such a way that the nerves of the leaves are perpendicular to each other. The leaves are glued together with cassava flour glue and left to dry between wire mesh sheets for 3 days. First one of the sheets is placed at the bottom of the crate, on top of this about two layers of tomatoes are placed, then another sheet and so on until the crate is filled. The choice for putting a sheet between every two layers of tomatoes instead of every layer of tomatoes is because farmers want to fit as many tomatoes in one crate as possible. This is because transport price is per crate. Therefore the solution should not take up too much space in the crate.



The crate is then placed on a bike and secured with a tension strap. After this, the test is performed by biking around on the bike. Since performing a test with a control group would require about double the amount of tomatoes the choice is made to base the results of the control group off of already performed research. Therefore to get valid results the test should closely resemble the tests of off which the control group is taken. Also the way of measuring is kept as close as possible to those methods of researching. The control group for quantitative post-harvest loss is 33% (Wongnaa et al., 2023), here weight before and after transport is measured, the tomatoes that are too damaged to be sold are disregarded. The control group for qualitative post-harvest loss is 55% damaged tomatoes (Dari et al., 2017), here damages such as bruises, rot, punctures, scratches or other damages are counted after transport.

The research of the paper looking into quantitative post-harvest loss (Wongnaa et al., 2023) is a large sized study performed in northern region of the Ashanti region in towns including Akumadan, Afrancho, and Nkenkaasu. Most transport is for local market but tomatoes are also transported to big cities. The biggest city in the Ashanti region is Kumasi and the distance from Kumasi to these towns is about 115 km. By car or truck in Ghana this would take about 2 and a half hours depending on the traffic. The research of the paper looking into qualitative post-harvest loss (Dari et al., 2017) is performed in the northern region of Ghana. Tomatoes arriving in Paga from Burkina Faso were sorted into damaged and undamaged, firm, healthy fruits. The undamaged fruits were packaged in crates with or without liners to be transported to Tamale, where the fruits were again sorted into damaged and undamaged tomatoes, resulting in the results of the research. The trip is 207 km, which would take about 3 hours and 50 minutes in Ghana depending on the traffic. Because biking the average distance of the distances of transport in the papers would take quite long and would leave the tomatoes exposed to the weather for longer than in the papers the choice is made to bike the average time of transport of the two papers. This means that the bike ride in the test will take 3 hours and 10 minutes. Transport in Ghana largely goes over partly paved roads with potholes causing vibrations and shocks in transport. The route that is chosen therefore contains the least amount of smooth paved road as possible to mimic the transport conditions in Ghana. Roads with either bumps or holes are chosen or cobbled roads instead of paved ones.



The average temperature in Kumasi throughout the year is 26°C and in Tamale 28°C (Weatherbase, 2024) which is an average of night and day together. Often transporters try

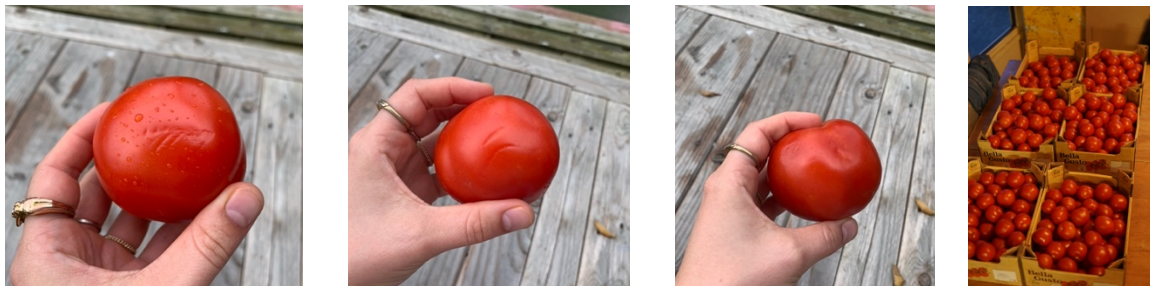
to drive in the mornings or the evenings when the sun is less strong and the temperature is lower since this is more beneficial for the tomatoes. Therefore the temperature during the transport tests from the papers above likely lies slightly below the averages of 26°C and 28°C. The difference between temperatures during the day and night are not too big with a variation ranging from 35°C during the day to 20°C at night throughout the year (WorldData, 2024). During the test the measured temperature was 26°C with sunny weather for about 2 hours and partly cloudy for the rest of the time. This temperature is compared to the temperatures in Ghana during transport an accurate temperature to do a test with.

16.2 Results post-harvest loss validation

Measuring the quantitative and qualitative loss of the test gives the following results:

Weight of tomatoes before transport	39 kg
Weight of tomatoes after transport	38 kg
Percentage of weight loss of tomatoes	2.5%
Weight of damaged tomatoes after transport	10 kg
Percentage damaged tomatoes after transport	25%

In the test, all tomatoes remained intact and very few showed damages visible on the outside such as rot, punctures and scratches. There were however dents and shrivelling visible and when taken out of the crate you can feel that some tomatoes had soft spots. Since all tomatoes were firm before transport these tomatoes are the ones that are counted as damaged tomatoes, visible below. In the picture with the boxes, the two boxes in the bottom row are counted as damaged.



Discussion

Compared to the control group both quantitative and qualitative loss are decreased as is visible above. If the results are interpreted directly from the numbers above quantitative loss is 30.5% less and qualitative loss is 30% less. However, since the control group is taken from existing research and this test is performed in different conditions an estimation of the quantitative and qualitative loss with the transport packaging sheets in Ghana needs to be made.

The conditions that need to be taken into account overall are:

- The difference in road quality between the Netherlands and Ghana. Although a big effort is made to take a route that includes irregularities it is still not exactly the same as in Ghana.
- The travelled distance is not the same, however the duration of the transport is.
- When transporting in a truck there are also vibrations of the motor, which are less than with a cargo bike.
- In a truck in Ghana more crates are transported at the same time, so there is more chance of heat building up which increases water loss and therefore quantitative loss.

- The crate used in the test is smaller than the crates used in Ghana, it does however have the same height and therefore the same weight pressing on top of the tomatoes.
- While temperature and weather conditions are very similar, humidity might differ.
- The most important difference is the quality of tomatoes. In Ghana tomatoes are usually already in a bad state before being transported, meaning they damage more easily when being transported. Next to this the quality of tomatoes in general is worse.

To come to a realistic estimation of the effect of the transport protection sheets on post-harvest loss both control group papers need to be compared with the test.

Estimated qualitative loss

In the paper where the control group is taken for qualitative loss a test is described with packaging liners in wooden crates with 50kg tomatoes. For this test only firm and healthy tomatoes were used imported from Burkina Faso. For the test jute hessian, paper or foam liners that are used to line the outside of the crate the results are 20% to 25% less damage (qualitative loss). When comparing this to the test, about the same amount of tomatoes, similar quality in tomatoes and a similar solution are used. Next to this the amount of tomatoes that is counted as damaged in the test still looks like they could be sold for full price. However, if these tomatoes would be of lesser quality as they are in Ghana, they would be more damaged and sold for less of the price. Therefore, an accurate estimation of the effect of the transport protection sheets would be 15-20% less qualitative loss.

Estimated quantitative loss

In the paper where the control group is taken for quantitative loss the results are obtained through a questionnaire and calculated by subtracting the quantity harvested minus the quantity that is sold. The loss is therefore not only a result of transport but also a result of handling by farmers, transporters and market women. The exact loss for the transport specific is therefore hard to determine. Other research states that 20% loss occurs during transport specifically (Bani et al., 2006). Next to this the heat buildup because of the amount of crates on one truck is also higher, resulting in more rapid water and therefore weight loss. In reality tomatoes are sometimes already damaged before going on the truck for transport while in the test only firm and healthy tomatoes were used who loose water less quickly. This means that during the test zero tomatoes would have to be discarded of because they can't be sold while in reality damages would be worse and at least a part would need to be totally discarded of because they can't be sold. The quantitative losses are therefore included below by formulating them as "sellable tomatoes". The difference in result between the test and the control group for quantitative loss is large. While 33% loss occurs in the control group 2.5% loss occurs in the test. Considering the quality of tomatoes, different transport conditions and estimated reduction in qualitative losses an estimation of the effect of the transport protection sheets would be 10% less quantitative loss. This is also in line with a test performed with lulo fruits where banana leaves were used as layers between fruits (Forero-Cabrera et al., 2017).

Appendix 17

Number of tomatoes per crate

With the use of the sheets there is slightly less space for the tomatoes in the crate than without the sheets. To see if this number is within the boundaries of the requirements and to see if this still allows for making profit with the use of the sheets the difference is calculated. The calculated number is combined with the expected decrease in post-harvest loss explained in appendix 16 to give an accurate number to calculate the effect on revenue.

17.1 Packing arrangements

When packing spheres or in this case tomatoes in a space there are different ways to do so resulting in different packing arrangements and packaging densities. Below, the calculations for determining the number of tomatoes in the crate with and without sheets is explained.

Close packing of equal spheres

The most efficient packing methods for equal spheres are face-centered cubic (FCC) and hexagonal close packing (HCP), both achieving the same packing efficiency (Weisstein, 2024). In both arrangements the packing efficiency is around 74.048% (Weisstein, 2024). So, by dividing the volume of the box multiplied with the packing density by the volume of the sphere you get the maximum amount of spheres in the box.

$$\text{OptimalEfficiency} = 0.74048$$

$$V_{\text{box}} = L \times W \times H$$

$$V_{\text{sphere}} = \frac{\pi d^3}{6}$$

$$\text{Max number of spheres} = \frac{\text{OptimalEfficiency} \times V_{\text{box}}}{V_{\text{sphere}}} = \frac{0.7405 \times LWH}{\frac{\pi d^3}{6}}$$

Tomatoes in a crate

To calculate the difference in number of tomatoes that can fit in a crate with and without the use of the transport protection sheets there are first some differences to point out. While the approach above considers the most efficient way of packing spheres into a box, the packing of tomatoes in crates in Ghana is less precise. Tomatoes are often thrown into a crate rather than placed into it in the most efficient way. Next to this, the approach above assumes spheres of equal size while tomatoes come in different shapes and sizes. For these reasons it is better to assume a different packing efficiency, in this case random loose packing (RLP).

Random loose packing

When spheres are placed in a box randomly without much effort to optimize space, this arrangement is known as random loose packing (Weisstein, 2024). This situation is realistic for when packing is done by hand or by randomly dropping spheres into a box. In this case the packing efficiency is 64% (Weisstein, 2024). Considering tomatoes are packed randomly and differ in size the packing efficiency of 64% is safe to assume. This comes down to the following equation.

$$\text{RandomEfficiency} = 0.64$$

$$\text{Random number of spheres} = \frac{\text{RandomEfficiency} \times V_{\text{box}}}{V_{\text{sphere}}} = \frac{0.64 \times LWH}{\frac{\pi d^3}{6}}$$

With this equation the number of tomatoes in a crate can be determined. For now, the volume for each individual tomato is generalised into an average volume per tomato. In Ghana the tomatoes are not too big. Next to this they are not perfectly round and can have flat sides or oval shapes. From my own experience at the market and supermarket in Ghana they have a diameter of 5 to 7 cm. Therefore, as a generalized number a diameter of 6 cm is taken for the tomatoes. With this number and the equation for random loose packing the amount of tomatoes in a crate without the use of the sheets can be determined for the standard crate sizes.

$$d = 0.06 \text{ m}$$

$$V_{\text{tomato}} = \frac{\pi d^3}{6} = 0.000113097 \text{ m}^3$$

$$\text{Number of tomatoes in crate} = \frac{\text{RandomEfficiency} \times V_{\text{crate}}}{V_{\text{tomato}}} = \frac{0.64 \times LWH}{0.000113097}$$

$$V_{\text{smallcrate}} = 0.6 \times 0.6 \times 0.6 = 0.216 \text{ m}^3$$

$$V_{\text{mediumcrate}} = 0.7 \times 0.7 \times 0.7 = 0.343 \text{ m}^3$$

$$V_{\text{largecrate}} = 0.8 \times 0.8 \times 0.8 = 0.512 \text{ m}^3$$

Crate size	Amount of tomatoes in the crate
0.6x0.6x0.6 m crate	1222
0.7x0.7x0.7 m crate	1941
0.8x0.8x0.8 m crate	2897

Packing with sheets

Now an estimation for the number of tomatoes in a crate with the use of sheets has to be made. Apart from the tomatoes a crate will now also include 8 transport protection sheets that divide the crate into several compartments. The sheets cover the full width and length of the box and have a thickness of approximately 1 cm without load. When a load is applied, the sheets are compressed to a thickness of 2 mm which is what happens when the crate is loaded with tomatoes.

In a packing arrangement of spheres in a box the space at the bottom and sides of the crate is the least densely packaged since the crate does not contain half tomatoes in those spaces. When sheets are placed between the layers it basically divides the crate into several individual spaces where the packing arrangement starts over. The tomatoes cannot fit neatly into each other since a sheet is placed in between. Since the crates of tomatoes will contain 8 sheets the crate will be divided into 8 smaller boxes. First the volume of the sheets in compression is subtracted from the total volume of the crate. Then the remaining volume is divided in to 8 parts. For each of the parts the number of tomatoes it contains

can be calculated and with that the total number of tomatoes fitting the crate when sheets are used.

$$V_{sheet} = L \times W \times H$$

$$\text{Number of tomatoes in crate with sheet} = 8 \times \frac{\text{RandomEfficiency} \times \frac{V_{crate} - 8 \times V_{sheet}}{8}}{V_{tomato}}$$

$$V_{smallsheet} = 0.6 \times 0.6 \times 0.002 = 0.00072 \text{ m}^3$$

$$V_{mediumsheet} = 0.7 \times 0.7 \times 0.002 = 0.00098 \text{ m}^3$$

$$V_{largesheet} = 0.8 \times 0.8 \times 0.002 = 0.00128 \text{ m}^3$$

Crate size	Amount of tomatoes in the crate with sheets
0.6x0.6x0.6 m crate	1190
0.7x0.7x0.7 m crate	1897
0.8x0.8x0.8 m crate	2839

One of the demands in the list of requirements states that the crate with the sheets should contain a minimum of 90% of the amount of tomatoes compared to the amount when sheets are not used. With the numbers above this can be calculated.

Crate size	Decrease in number of tomatoes per crate with the use of sheets
0.6x0.6x0.6 m crate	2.6%
0.7x0.7x0.7 m crate	2.3%
0.8x0.8x0.8 m crate	2.0%

This means that the decrease in number of tomatoes per crate with the use of the transport protection sheets fall well within the requirements. On average 2.3% less tomatoes can fit in the box. This is the number that will be taken into account when calculating the increase in revenue and the payout time.

17.2 Expected decrease in post-harvest loss

Like explained in appendix 17.1 less tomatoes fit in the crate when the sheets are used. On average for the different crate sizes this is 2.3% less tomatoes. This means per crate 2.3% less tomatoes can arrive at the market. This number should be taken into account in the estimation of amount of sellable tomatoes. Below the final numbers for the expected decrease in post-harvest loss resulting from the post-harvest loss validation test and decreased amount of tomatoes fitting in the crate are visible.

Quantitative and qualitative loss	Percentage
Percentage of damaged tomatoes from the comparison study (%) (Dari et al., 2017)	55%
Amount of sellable tomatoes from the comparison study (%) (Wongnaa et al., 2023)	67%
Percentage of damaged tomatoes from validation test (%)	25%
Amount of sellable tomatoes from validation test (%)	98%
Expected percentage of damaged tomatoes with the use of the solution in Ghana (%)	35%
Expected amount of sellable tomatoes with the use of the solution in Ghana (%)	75%

Difference between seasons

Losses differ per season since price, supply and demand differ in the major and minor seasons. In the major season, demand is lower and supply is higher, resulting in more losses while demand in the minor season is high and supply lower, resulting in a higher portion of the harvest being sold. The difference in quantitative post-harvest loss between the seasons can lie around 20% (Wongnaa et al., 2023). If this is applied to the expected amount of sellable tomatoes with the sheets you get the following numbers for post-harvest loss per season.

Quantitative loss estimated per season	Percentage
Amount of sellable tomatoes from comparison study average per year (%) (Wongnaa et al., 2023)	67%
Amount of sellable tomatoes from comparison study in major season (%) (Wongnaa et al., 2023)	57%
Amount of sellable tomatoes from comparison study in minor season (%) (Wongnaa et al., 2023)	77%
Expected amount of sellable tomatoes with the use of the solution in Ghana average per year (%)	75%
Expected amount of sellable tomatoes with the use of the solution in Ghana in major season (%)	65%
Expected amount of sellable tomatoes with the use of the solution in Ghana in minor season(%)	85%

Appendix 18

Effect on revenue

The effect of the expected decreased post-harvest loss throughout the year on revenue results at wholesale level:

	Major season		Minor season	
	GH¢	€	GH¢	€
Unit price per 100 kg tomatoes in northern Ashanti region (Wongnaa et al., 2023)	51,61	2.99	307.70	17.85
Turnover obtained in control group for 100 kg harvest with 67% sellable tomatoes	34.58	2.01	206.16	11.96
Turnover obtained with sheets for 100 kg harvest with 77% sellable tomatoes	38.71	2.25	230.78	13.38
Potential increased revenue with prototype (%)	12%		12%	

Since price, supply and demand differ in the major and minor season, losses usually also differ per season. In the major season demand is lower and supply is higher, resulting in more losses while demand in the minor season is high and supply lower, resulting in a higher portion of the harvest being sold. The difference in quantitative post-harvest loss between the seasons can lie around 20% (Wongnaa et al., 2023). The difference in qualitative loss between the seasons is unknown.

The effect of the expected decreased post-harvest loss estimated per season on revenue results at wholesale level:

	Major season		Minor season	
	GH¢	€	GH¢	€
Unit price per 100 kg tomatoes in northern Ashanti region (Wongnaa et al., 2023)	51.61	2.99	307.70	17.85
Turnover obtained in control group for 100 kg harvest	29.42	1.71	236.93	13.74
Turnover obtained with sheets for 100 kg harvest	33.55	1.95	261.55	15.17
Potential increased revenue with prototype (%)	14%		10%	

The effect of the expected decreased post-harvest loss throughout the year on revenue results at market level:

	Major season		Minor season	
	GH¢	€	GH¢	€
Unit price undamaged tomatoes at local market for 100 kg in Kumasi (appendix 5.1)	200	11.60	350.00	20.30
Unit price damaged tomatoes at local market for 100 kg (1/4 of the price of undamaged (appendix 5.1))	50.00	2.90	87.50	5.08
Turnover obtained in control group for 100 kg tomatoes	117.50	6.82	205.63	11.93

Turnover obtained with sheets for 100 kg tomatoes	147.50	8.56	258.13	14.97
Potential increased revenue with prototype (%)	26%		26%	

After transport the sheets were assessed on their ability to be reused. Out of the 5 sheets 4 were still in one piece and one sheet lost one leaf piece. The sheets where thicker, more stiff leaves were used come apart easier than the thinner leaves. Overall, the sheets have become more dented and deformed and are less flat than before the test. They look a bit more rugged but could still be used for another round of transport since they do keep their damping abilities.



Appendix 19

Cost and price

To estimate the payout time for farmers the fixed and variable costs need to be taken into account. Below initial investment and investment per sheet are calculated to eventually estimate a payout time. All costs of materials are obtained from the project manager of ACHI in Ghana. The drying rack can be stacked. This means that several layers of wire mesh racks can be stacked on top of each other instead of making two racks for every layer of sheets drying. For example, 4 sheets can be dried between two racks, 8 can be dried between 3 racks, 12 can be dried between 4 racks and so on.

Cost for 1 side of a stacked drying rack of 120 by 120 cm

Material	Price in GHC	Amount	Cost in GHC
Wooden slat, 300 cm long, profile of 2.5 by 5 cm	25.00	2.00	50.00
Wire mesh roll, 120 cm by 914 cm	300.00	0.14	42.00
200 nails	100.00	0.02	2.00
350 staples	200.00	0.05	9.52
Total cost for 1 stacked drying rack of 120 by 120 cm			103.52

Cost for leaf cutting stencils

Material	Price in GHC	Amount	Cost in GHC
Wooden plate, 120 by 214 cm	80.00	0.20	16.00
Wooden plate, 120 by 214 cm	80.00	0.06	4.80
Total cost for a large and a small leaf cutting stencil			20.80

Cost for glue 500 ml glue, good for 10 sheets

Material	Price in GHC	Amount	Cost in GHC
Water, 500 ml	2.00	1.00	2.00
Cassava flour, 1 kg	10.00	0.10	1.00
Sugar, 1 kg	40.00	0.15	6.00
Vinegar, 1 iter	30.00	0.02	0.60
Baking soda, 500 gram	20.00	0.03	0.60
Total cost of glue for 10 sheets			8.20
Total cost of glue for 1 sheet			0.82

With this information the fixed and variable costs can be calculated, the fixed cost consist of a small and large wooden stencil to cut leaves in the right size, this is always needed only once. The cost for the drying racks is also fixed but depends on the size of the harvest. First an example is given for the fixed costs and the costs per sheet, after that payout with and without reuse are calculated.

Initial investment to dry 8 sheets at a time

Material	Price in GHC	Price in €
Stacked drying rack with 3 layers	310.57	18.01
Large leaf cutting stencil for full sheet	16.00	0.93
Small leaf cutting stencil for cutting leaf pieces	4.80	0.28
Total initial investment		19.22

Investment per sheet

Material	Price in GHC	Price in €
----------	--------------	------------

Banana or plantain leaves	0.00	0.00
50 ml of glue	0.82	0.05
Total investment per sheet	0.82	0.05

Revenue, costs and profit of the average farmer are taken from Wongnaa et al., 2023. This is also the paper from which the control group for quantity loss was taken. Not all commercial smallholder farmers do bookkeeping so it is hard to get revenue numbers. In the paper the numbers are taken from a large survey. From this the revenue, costs and profits are calculated for the farmer with the average amount of land of 1.68 ha. For this the results are 1.6 months of payout time if sheets are not reused and 0.6 months of payout time if the sheets are reused two times, which is in total 3 use cycles.

Payout time with or without reuse of the sheets for the average farmer

Cost	Price in GHC	Price in €
Total revenue for major and minor season together (Wongnaa et al., 2023)	9345.60	542.04
Total cost of production for major and minor season together (Wongnaa et al., 2023)	2759.94	160.08
Total revenue for major and minor season together with use of sheets	10467.07	607.09
Total profit for major and minor season together with use of sheets	7707.13	447.01
Total profit per month with use of sheets	642.26	37.25
Amount of medium sized crates sold per year with use of sheets	282	
Amount of sheets necessary per month without reuse	188	
Desired amount of sheets drying at a time without reuse (production of 48 per week)	24	
Initial investment for drying rack without reuse	724.67	42.03
Amount of sheets necessary per month with reuse of 3 times	63	
Desired amount of sheets drying at a time with reuse of 3 times (production of 16 per week)	8	
Initial investment for drying rack with reuse of 3 times	310.57	18.01
Initial investment for cutting stencils	20.80	1.21
Initial total investment without reuse	745.47	43.24
Initial total investment with reuse of 3 times	331.37	19.22
Investment per sheet	0.82	0.05
Investment per month in sheets without reuse for average farmer	153.99	8.93
Investment per month in sheets with reuse of 3 times for average farmer	51.33	2.98
Payout time in months without reuse of the sheets for the average farmer	1.6	
Payout time in months with reuse of 3 times of the sheets for the average farmer	0.6	

Appendix 20

Stakeholder validation

To assess the desirability and feasibility of the final design it needs to be validated by stakeholders within the project. The stakeholders that are included in the validation are commercial smallholder farmers, KAC staff and HGT staff. The design is evaluated through interviews with the previously named stakeholders as well as an online questionnaire.

20.1 Interview questions stakeholder validation

You will answer questions about the following solution:

Using banana leaves as transport protection sheets for tomatoes in crates that you can produce at your own farm.

Effect and investment

- *Reduces weight loss of tomatoes during transport by 10%*
- *Reduces damages to the tomatoes during transport by 15-20%*
- *The reduction in damages means 13-18% increase of revenue at wholesale level*
- *The reduction in damages means 19-26% increase of revenue at market level*
- *Requires +/- 520 cedi initial investment (depending on farm size)*
- *Requires 6.5 cedi per crate of tomatoes*
- *This means profit is made after about 0.5 month if sheets reused and after 1.5 month if sheets are used only once*

Would you want to use this solution? Why or why not?

Would you be willing to make this investment for this effect? Why or why not?

Do you think this is a big or small investment?

Is the cost per packaged crate okay for you? Why or why not?

Is the payout time feasible or does it need to be more or less?

To produce the solution the following is important

Effort and production

- *Takes 1 extra minute in packaging time per crate*
- *To make the sheets you need banana leaves and ingredients for natural glue: cassava flour, sugar, vinegar*
- *Production of transport protection sheets requires the user to clean, cut and boil banana leaves, makes natural glue and glue leaves together*
- *Production of 8 transport protection sheets per crate takes 40 min time and 3 days waiting time. They can be used for at least three transport cycles.*
- *To make the drying racks needed to make the sheets you need wooden slats, a wooden plate, wire mesh, nails and staples*
- *Production of drying racks (only once) takes 4 hours time and requires skills like sawing wood, nailing wood and wire mesh*
- *Can be reused for transport if brought back to the farm for packaging the crates*
- *The sheets last for at least 5 weeks or 3 use cycles*

For the previously named results would you use the solution if it requires the efforts above?

Is the production of the transport protection sheets per crate feasible for you if it includes a guide?

Do you consider the production of the transport protection sheets as easy?

Is it possible for you to obtain the materials for the transport protection sheets?

Is the production of the tool feasible for your if it includes a guide? Why or why not?

Do you consider the production of the tool as easy? Why or why not?

Is it possible for you to obtain the materials for the tool? And where would you get them?

20.2 Results stakeholder validation interviews

15-08-2024

Project manager ACHI Ghana

Meeting summary

Overall, he thinks the idea is nice, but has some questions. He says that farmers sometimes already use banana leaves to line crates but then they are fresh, rip easily and are discarded after transport. Therefore, a solution that lasts longer is a good one which he thinks is more sustainable. Since the leaves grow in abundance in Ghana and are mostly free it is a good solution price-wise as well. The effect and design of the design are nice but he voices concerns about the adoption of the solution of farmers. He says sometimes adoption of things can be slow because of the system in Ghana. He thinks this specific solution where farmers make the sheets themselves could work for more small-scale farmers that produce smaller quantities. On the other hand for the farmers producing bigger quantities, it really depends on some factors. First of all, how many times the solution can be used is very important. Since this solution asks the farmers to invest time and effort it needs to be worth it for them. If the sheets are lost after using them one time it is too much effort and investment. Therefore, he thinks ideally it would be better if the sheets are sold to farmers. After discussing ideas together we came to a good option. The idea is to first present the current solution to farmers and students. Ideally there is one person (or more) who start a business in manufacturing the sheets by upscaling production in a more professional way. Since in this way there is less limit to budget, more investment can be made in more high-end tools and manufacturing techniques. Then the sheets can just be sold to farmers which makes it very likely that larger scale and smaller scale farmers will adopt such a solution.

19-08-2024

The ACHI project coordinator Ghana, project coordinator ACHI Ghana

Meeting summary

To start of he thinks it is a very innovative, well created solution that sounds doable. He thinks it is also nice that sheets are placed in between layers instead of as liners on the sides since this allows for ventilation. After asking some questions these areas of the project are more thoroughly explained. Especially the test, investment and production are discussed in detail. The information worth noting is the following. First we talked about the current use of banana leaves when packaging kenkey or banku, here the leaves are also first heated before used, this makes them more flexible. It is nice that this is a familiar way of treating the banana or plantain leaves. The test was nice but of course not directly translatable to Ghana, we talked mainly about the difference in amount and quality of tomatoes. The current estimated results seem good, but would need to be confirmed with tests in Ghana. The named investment is alright, not too high so that is very great, especially if sheets can be reused and stay in one piece during transport. The last thing is that 40 min might be a bit much for production time. For the farmers own production it might be high if the sheets are not reused but if they are reused he thinks it is okay. If someone would like to take up making these sheets as a business 40 minutes would most definitely be too much so that would need to be brought back with a different way of production of the sheets.

19-08-2024

Farmer in Kumasi area, owner of Fresh from farms

Meeting summary

Overall she thinks the idea is innovative and easy to produce. In some cases glue from cassava starch is already used in Ghana so she thinks it is nice that that is familiar and also natural/biodegradable. She says usually this glue does not stay good for a very long time so this needs to be taken into consideration. The glue needs to either stay good for longer or people need to work around this. Next to this it is very nice that all the materials are readily available in Ghana and relatively cheap. Overall, she thinks if the sheets have the effect that they claim to have now the effort and investment are right for farmers. Then the investment, effort and time put into it are worth it. Ideally it would be better if production was a bit shorter than estimated. To see if the solution actually has the expected effect she would like to see a pilot with farmers in Ghana. This makes it more realistic. Lastly there is one concern about targeting of the solution. The people who usually take care of the transport are market women, so they might be more motivated to use the sheets than farmers. But on the other hand she thinks the market women would not be the ones who would produce the sheets themselves. She thinks it is important that people can first try the solution to see the results before investing if that is a possibility. After discussing this together 3 options to introduce the solution to different people came forth:

- Include the crate manufacturers in the process. When market women or farmers buy the wooden crates at the crate factory the manufacturers could introduce or sell the sheets to them. Maybe they can first give a free sample to test.
- Another option is introducing it to the farmers who make the sheets and sell them to market women who come to buy their product or sell their produce for more money after they have first showed the effect to the market women by testing it.
- Another way would be to market the sheets directly to market women at transport places. This could be done by someone who makes a business out of making the sheets. Here again a free sample could be provided.

19-08-2024

Farmer in Volta region

Meeting summary

She thinks it is nice that the sheets are natural and organic. This is safe and good for the produce it packages and no plastic is used. Some farmers use similar solutions such as lining crates with grass. This however becomes a problem when the pressure becomes too much and the weather gets hotter, then it could destroy the tomatoes. Therefore the sheets could be nice for this. This is also her main concern. Since the sheets are tested in the Netherlands and an effort is made to mimic conditions in Ghana it is still not the same. A test in Ghana would be necessary to really validate the design. She is concerned whether the sheets would still hold during hot weather when more tomatoes spoil and more moisture is lost. She thinks for this effect the investment would be good but there would maybe be a problem with the time and effort that needs to be spend on this. The most important thing for introducing these sheets to farmers would be to convince the farmers

that this option is worth it to put the work and investment in over just using the grass. Because although it does not work optimally it is very easy. It is therefore important that a good value proposition is made. A good look should be taken at the business model of the sheets and the unique value of using the sheets such as for example that it is more safe and hygienic than using grass and that it could enhance taste or be reused. Overall a solution is a good solution for farmers if it is cheap, quick and reusable. She is willing to see if someone can perform a quick test in Ghana with the sheets to have a better validation of the design.

20-08-2024

Holland Grentech manager Ghana

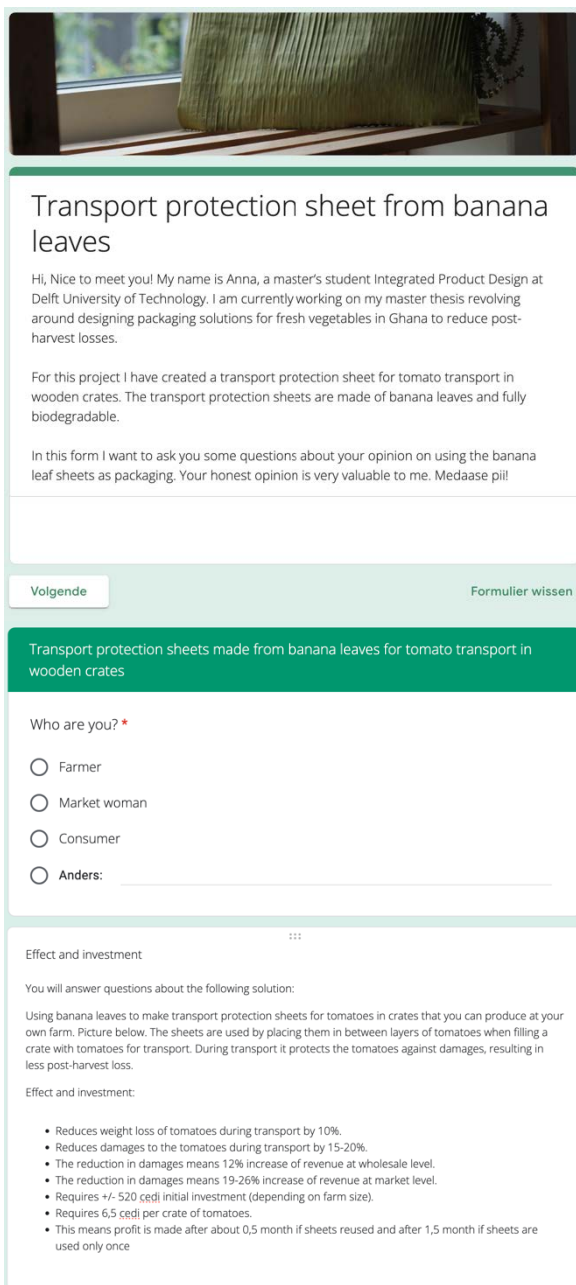
Meeting summary

Overall she likes the idea and thinks it is a good innovative option. However if she looks from the business side she has some questions. The first one is about production volumes and if it can be used for larger quantities since this is not exactly tested. This is no problem, larger sheets can be made but if farmers produce high volumes of tomatoes the production of sheets might take a lot of time. Next to this she mentions that leaves are also used for wrapping foods and that it is important to think about the fact that this is competition in the market and that you have to see if high production volumes create scarcity. For this reason reuse of the sheets would also be very good. When looking at the effort and time that is required from the farmers she thinks that it would depend on the type of farmer if they would be willing to do that. Some would likely want to produce the sheets themselves while others would prefer to buy them. She thinks this would be price related. If you look at the entrepreneurship part it could be nice that someone turns making the sheets into a business. Financially it really depends on the farmer whether it is feasible or not. Next to this the sheets could also be interesting for middle women since they also take care of transport. She thinks they would not want to make the sheets themselves but would like to buy them.

For market women around 45-100 crates of tomatoes arrive a day in the high season. Depending on the size of the farm 10-40 crates are harvested and transported per load from 1 farm. A small farm would produce about 10 crates at a time and a large farm 40. This happens usually once a week for 4 weeks for tomatoes.

20.3 Questionnaire set-up stakeholder validation

This questionnaire was set-up to validate the transport protection sheets with stakeholders in Ghana. It is meant to validate the design on several aspects. First the participant is presented with information about the effects the sheets have on post-harvest loss and what investment is required. This is accompanied by an explanation and picture of the design. After this questions are asked about whether the user would want to use the design and what they think about the investment. By first asking this the willingness to use this solution and the price can be validated. After this some more information is provided about the production activities and the effort this takes. Then the participants are asked about their willingness to produce the solution and what they think about the level of difficulty. This helps validate whether the stakeholder think the work is appropriate for the solution.



Transport protection sheet from banana leaves

Hi, Nice to meet you! My name is Anna, a master's student Integrated Product Design at Delft University of Technology. I am currently working on my master thesis revolving around designing packaging solutions for fresh vegetables in Ghana to reduce post-harvest losses.

For this project I have created a transport protection sheet for tomato transport in wooden crates. The transport protection sheets are made of banana leaves and fully biodegradable.

In this form I want to ask you some questions about your opinion on using the banana leaf sheets as packaging. Your honest opinion is very valuable to me. Medaasee pii!

Volgende Formulier wissen

Transport protection sheets made from banana leaves for tomato transport in wooden crates

Who are you? *

Farmer

Market woman

Consumer

Anders: _____

Effect and investment

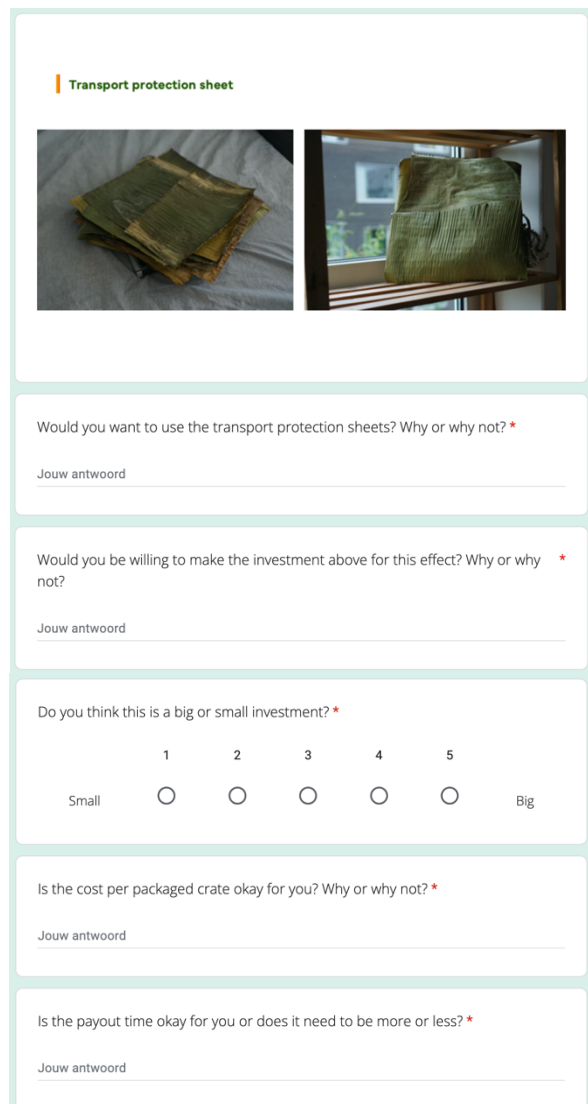
You will answer questions about the following solution:

Using banana leaves to make transport protection sheets for tomatoes in crates that you can produce at your own farm. Picture below. The sheets are used by placing them in between layers of tomatoes when filling a crate with tomatoes for transport. During transport it protects the tomatoes against damages, resulting in less post-harvest loss.

Effect and investment:

- Reduces weight loss of tomatoes during transport by 10%.
- Reduces damages to the tomatoes during transport by 15-20%.
- The reduction in damages means 12% increase of revenue at wholesale level.
- The reduction in damages means 19-26% increase of revenue at market level.
- Requires +/- 520 cedi initial investment (depending on farm size).
- Requires 6,5 cedi per crate of tomatoes.
- This means profit is made after about 0,5 month if sheets reused and after 1,5 month if sheets are used only once

1



Transport protection sheet

Would you want to use the transport protection sheets? Why or why not? *

Jouw antwoord _____

Would you be willing to make the investment above for this effect? Why or why not? *

Jouw antwoord _____

Do you think this is a big or small investment? *

Small 1 2 3 4 5 Big

Is the cost per packaged crate okay for you? Why or why not? *

Jouw antwoord _____

Is the payout time okay for you or does it need to be more or less? *

Jouw antwoord _____

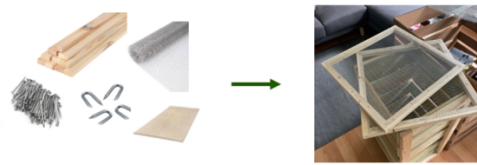
2

Effort and production

To produce the solution the following is important

- Takes 1 extra minute in packaging time per crate
- To make the sheets you need banana leaves and ingredients for natural glue: cassava flour, sugar, vinegar
- Production of transport protection sheets requires the use to clean, cut and boil banana leaves, makes natural glue and glue leaves together
- Production of 8 transport protection sheets per crate takes 40 min time and 3 days waiting time.
- They can be used for at least three transport cycles.
- To make the drying racks needed to make the sheets you need wooden slats, a wooden plate, wire mesh, nails and staples
- Production of drying racks (only once) takes 4 hours time and requires skills like sawing wood, nailing wood and wire mesh
- The sheets can be reused for transport if brought back to the farm for packaging the crates
- The leaves last for at least 5 weeks and at about 3 use cycles

Production of the tool



For the previously named results would you use the transport protection sheets * if it requires the efforts above? Why or why not?

Jouw antwoord _____

If it includes a guide do you think you could make the transport protection sheets yourself? * Why or why not?

Jouw antwoord _____

3

Do you think the production of the transport protection sheets is easy? *

Easy 1 2 3 4 5 Hard

Where would you get the materials for the transport protection sheets? *

Jouw antwoord _____

If someone would sell these transport protection sheets already made, would * you buy them? Why or why not?

Jouw antwoord _____

How much would you pay per sheet? *

Jouw antwoord _____

If it includes a guide do you think you could make the tool yourself? * Why or why not?

Jouw antwoord _____

Do you think the production of the tool is easy? *

Easy 1 2 3 4 5 Hard

Where would you get the materials for the tool? *

Jouw antwoord _____

Vorige **Verzenden** Formulier wissen

4

20.4 Questionnaire results stakeholder validation

	A	B	C	D	E	F	G	H	I	J
1	Who are you?	Farmer	Farmer	Farmer	Farmer	Farmer		Consumer	Consumer	Consumer
2	Would you want to use the transport protection sheets? Why or why not?	Yes	Yes, It will help me reduce losses during transportation	Yes if it possibly reduce spoilage	yes	Yes, because the rate at which our tomatoes get damaged when transporting is very painful.		Yes, because it will serve as cushion for the product	Yes. Very economical and environmentally friendly	Yes
3	Would you be willing to make the investment above for this effect? Why or why not?	Yes. Less loss equals more money	Yes, it will increase my profit	Yes to reduce cost	yes- because we should not waste food and we must secure farmers income	Yes		Yes, to help minimize losses	Yes, because it will safe our environment	I'm not a farmer
4	Do you think this is a big or small investment?	2	1	5	1	2		4	3	4
5	Is the cost per packaged crate okay for you? Why or why not?	Yes. It's affordable	Its okay, considering the benefit I will derive from it	Yes, it's Okey per the material cost	yes	Yes		High	Yea, environment friendly	It will depend on how many fruits there are in the crate
6	Is the payout time okay for you or does it need to be more or less?	Less	Its okay for me	It's okey	Fine, I dont grow tomatoes yet- but all foods should be protected during transport	Not bad		No, needs to be more for initial stage	We have to create awareness to the general public before wile will be able to think of cash out	Lrss
7	For the previously named results would you use the transport protection sheets if it requires the efforts above? Why or why not?	Yes. It's efficient	Yes I will use because the efforts required to make the sheet is less	Yes for the fact that it will protect the produce better and maintain quality	Yes	I will because it'll probably protect my produce		Yes	No, the materials needed will be quite expensive	Yes
8	If it includes a guide do you think you could make the transport protection sheets yourself? Why or why not?	Yes.	Yes a guide will make it easy to produce the sheet myself	Yes	Sure, we could	I can		Yes. This will allow others adopt the use of this idea.	Yea, because the materials are really available	Yes
9	Do you think the production of the transport protection sheets is easy?	1	2	5	1	3		3	2	3
10	Where would you get the materials for the transport protection sheets?	Local	Anyone who will be offering it or the government can supply for free	My farm	timber market and hardware store, plus bananas from the field	I have them in my surroundings		The banana leaves are available for free in various plantation farms but nails, glue and wood have to be bought	From my backyard garden	The market
11	If someone would sell these transport protection sheets already made, would you buy them? Why or why not?	Yes. Economic value	Yes, I guess it would be affordable and able to reduce some amount of post harvest loss	Yes depending on the cost	Location, distance	Yes		Yes for storage	Yea I will buy , if it serve the purpose of whatever am doing	Not applicable
12	How much would you pay per sheet?	5 l cedis		Anything amount around 2% of the current production cost is Okey considering the extra protection it will to the produce	10 ghs	It depends		10-15 for consumable size	Based on the quantity	Not applicable
13	If it includes a guide do you think you could make the tool yourself? Why or why not?	Yes	Yes, a guide will help me follow the instruction to produce the sheets	Yes, the guide	sure	Yes		Yes	Yea	Not applicable
14	Do you think the production of the tool is easy?	3	2	3	1	3		3	3	3
15	Where would you get the materials for the tool?	Local	In a friends plantain farm	My farm and market	timber market and hardware store, plus bananas from the field	In my area		From farm and sale shops	From the local market	Market

20.5 Questionnaire conclusions stakeholder validation

Below the results of the questionnaire are analysed. Despite of spreading the questionnaire in facebook groups about farming in Ghana, in the Holland Greentech network, the KAC network and my personal contacts acquired in Ghana the questionnaire was filled in only 8 times after reaching out for 3 weeks. The results will be analysed with this small sample size in mind. Out of the 8 respondents 5 are farmers and 3 are customers. Unfortunately it was not possible to find market women for the questionnaire.

Effect and investment

All participants state they would use the solution and are on board for the named investment, reasons are the reduction of losses and spoilage and it is economically and environmentally friendly. They state they would be okay with the investment since it will increase profit, minimize losses and save the environment.

"Yes, because the rate at which our tomatoes get damaged when transporting is very painful."

"Yes- because we should not waste food and we must secure farmers income."

"Yes. Less loss equals more money."

The opinion on whether the initial investment is small or big is very evenly divided. 50% of the people rate it on the lower side while 37.5% rates it on the higher side. This is likely has to do with the individual budget of the respondent. Next to this it stands out that customers rate the investment significantly higher than farmers. The investment per crate is okay for all respondents. Overall the payout time is okay as well by most respondents with one saying it should be less and one saying it should be more.

Effort and production

After presenting the efforts necessary to produce the sheets 7 out of 8 respondents would still use them and one person (customer) says they would not anymore.

"Yes I will use because the efforts required to make the sheet is less."

"Yes for the fact that it will protect the produce better and maintain quality."

With the help of a guide all participants feel confident that they could produce the transport protection sheets themselves. 37.5% rates it neutral on how hard it would be, 50% rates it on the easier side and 12.5 on the hard side. They also feel confident that they could build the tools with the help of a guide. Here 75% rates it neutral on difficulty and 25% rates it on the easier side. They would get the materials for the tools from either the market or the hardware store and the leaves from their own or other farms.

"The banana leaves are available for free in various plantation farms but nails, glue and wood have to be bought."

"timber market and hardware store, plus bananas from the field."


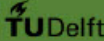
If the sheets were available to just buy all respondents state they would do it for reasons like the economic value it has and the possible reduction of losses. What they would pay per sheet would depend on the quantity and in the survey ranges from 1 to 15 cedi per sheet.

" Yes, I guess it would be affordable and able to reduce some amount of post harvest loss."

" Anything amount around 2% of the current production cost is Okey considering the extra protection it will to the produce."

Appendix 21

Project brief IDE Master Graduation Project

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME

Complete all fields and indicate which master(s) you are in

Family name	Koper	7105	IDE master(s) IPD	<input checked="" type="checkbox"/>	Dfi	<input type="checkbox"/>	SPD	<input type="checkbox"/>
Initials	A		2 nd non-IDE master					
Given name	Anna		Individual programme (date of approval)					
Student number	4668391		Medisign	<input type="checkbox"/>				
			HPM	<input type="checkbox"/>				

SUPERVISORY TEAM

Fill in the required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Wilfred van der Vegte	dept./section	SDE	<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.</div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.</div> <div style="border: 1px solid #ccc; padding: 5px;"> 2nd mentor only applies when a client is involved.</div>
mentor	Eliza Noordhoek	dept./section	HCD	
2 nd mentor	Lindsey Schwidder			
client:	Kwadaso Agricultural College			
city:	Kumasi	country:	Ghana	
optional comments				

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in by the Chair of the supervisory team

Sign for approval (Chair)


Digitally signed by Wilfred van der Vegte
Date: 2024.03.22 11:50:10 +01'00'

Name Wilfred van der VegteDate 22 Mar 2024Signature _____

CHECK ON STUDY PROGRESS

To be filled in by SSC E&SA (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total _____ EC

Of which, taking conditional requirements into account, can be part of the exam programme _____ EC

★	YES	all 1 st year master courses passed
	NO	missing 1 st year courses

Comments:

Sign for approval (SSC E&SA)

Robin den
Braber

Digitaal ondertekend
door Robin den Braber
Datum: 2024.03.28
09:31:35 +01'00'

Name Robin den Braber

Date 28 mrt 2024

Signature _____

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	ALLOWED to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Monique
von Morgen

Digitally signed by
Monique von Morgen
Date: 2024.03.28
11:30:10 +01'00'

Name Monique von Morgen

Date 28 Mar 2024

Signature _____



Personal Project Brief – IDE Master Graduation Project

Name student Anna Koper

Student number 4,668,391

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title Designing a fresh vegetable packaging solution for Ghanaian smallholder farmers

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Ghana's horticulture sector is ripe with opportunity and holds potential to create jobs as well as addressing food security and safety, yet there is a challenge to overcome. A critical gap exists between theoretical knowledge taught in classrooms and practical skills needed to thrive as a climate-smart horticulture entrepreneur. To bridge this gap, 3.5 years ago Delft University of Technology (TU Delft) joined forces with Kwadaso Agricultural College (KAC) in Kumasi and Holland Greentech Ghana (HGT) under the Archipelago program. My project is part of a 4 year project within the program, ACHI, where collaboration will expand to 4 other schools in Ghana. The main focus here is providing practical climate-smart training and resources with HGT's agronomists and business and entrepreneurship education supported by the Delft Centre for Entrepreneurship, to help transform KAC's curriculum. However, a significant challenge remains: post-harvest losses in Ghana are estimated to rise to 50% (Saavedra et al., 2014) depending on the crop. Limited adoption of packaging practices among Ghanaian farmers is a major contribution to this issue. There the opportunity arises to improve education on this topic for KAC. It's important to acknowledge the limitations inherent to working in Ghana. Since I will only be in Ghana for a part of the project it is important for me to carefully plan the collaboration with local stakeholders to retrieve accurate information. I believe this will require extra effort from me, but expect promising opportunities for collaboration when looking at previously conducted projects under the Archipelago program.

Saavedra, Y., Dijkxhoorn, Y., Elings, A., Glover-Tay, J., Koomen, I., Van Der Maden, E., . . . Obeng, P. (2014). Vegetables Business Opportunities in Ghana: 2014. Wageningen University & Research.

→ space available for images / figures on next page

introduction (continued): space for images



image / figure 1 Archipelago project in Kumasi, Ghana



image / figure 2 Successfully completed project in Ghana: Building a solar dryer for chilli peppers to increase harvest value

Personal Project Brief – IDE Master Graduation Project

Problem Definition

*What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)*

Combatting post-harvest losses is crucial for ensuring financial security among commercial smallholder farmers. Packaging practices aren't widespread among Ghanaian farmers and combined with the climate, transport and lack of good storage space products have a short shelf life. The challenge lies in designing a packaging solution that serves as a model for horticulture students, stressing the benefits of packaging such as extending shelf life, improving product quality and saving precious resources. Additionally, the solution can help establish financial security by igniting a sense of creativity and entrepreneurship among farmers and students by posing the opportunity to showcase one's farm and establish a recognizable brand in a crowded market through packaging.

Ultimately, packaging produce motivates more sustainable, future-proof farming practices. When losing produce post-harvest, hard work and time put into farming as well as resources such as water, fertiliser, pesticides and nutrients are wasted. Minimizing this loss while stimulating entrepreneurship will get the most out of their hard work and used resources which will increase the total value of the harvest. Given the context, the packaging solution should be buildable in the local context with local materials and should explore options for sustainable packaging (for example reusable/biodegradable/compostable/recyclable etc.) while being financially feasible.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Design and prototype a packaging solution for Ghanaian smallholder farmers to decrease post-harvest losses, that can be built with local materials and educates students at KAC on the importance and benefits of packaging.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

The first step is to properly understand the current context, situation and all involved stakeholders to find out why people are not packaging, where and why the post-harvest losses occur, what the available resources are and where the opportunities are for a packaging solution. To properly research this I will spend time in Ghana during the first half of the project to conduct field research in the form of interviews, observations and tests in the context such as at KAC, on farms, local markets and supermarkets. This will be my main focus before my mid-term as well as moving into the early design phase by doing co-creation with local stakeholders to make optimal use of my time in Ghana. Continuing into the design and conceptualisation phase after my mid-term I want to focus on designing by doing. Making prototypes helps me iterate and improve upon concepts faster and in a richer way by being able to experience and test them immediately. During the whole project I want to take the values and principles of agile design into account to accelerate the process and maintain flexibility.

Project planning and key moments

To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting, mid-term evaluation meeting, green light meeting and graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	21 mrt 2024
Mid-term evaluation	28 mei 2024
Green light meeting	29 aug 2024
Graduation ceremony	26 sept 2024

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	<input checked="" type="checkbox"/>
For how many project weeks	20
Number of project days per week	4,0

Comments:

I have a side-job for one day a week, which means my graduation project will take 25 weeks instead of 20 and I will take a holiday twice of in total 3 weeks.

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.

(200 words max)

This project excites me for a few reasons. First, it feels like a good blend of using my existing skills and learning new ones. I enjoy the challenge of bringing together stakeholder needs and finding creative solutions that work for everyone. Since this is a new context for me, I know I'll need to be extra thorough in my research and avoid any personal biases.

What I love the most about this project is the chance to make a real difference. It's an opportunity to develop a tangible product that improves people's living standards and could be of great value for those who really need it.

I enjoy the prototyping and creation phase most, especially when it comes to crafting simple yet effective solutions. This project will push me outside my comfort zone, as I've never prototyped objects of this nature before.

My learning ambition is to understand the context optimally through expanding my field research skills to ensure a truly useful solution. Additionally, I'd love to improve my ability to translate my thoughts into clear and concise words and visuals to accurately convey what is happening in my head.