



Students' perceptions of genetically modified organisms

What is required to increase acceptance?

Emma Lif

Master's thesis project – 30 credits

Faculty of Landscape Architecture, Horticulture and Crop Production Science

Independent Project in Agricultural science, A2E – Agroecology Master's Programme

Alnarp, Sweden

2023



Students' perceptions of genetically modified organisms

What is required to increase acceptance?

Emma Lif

Supervisor: Anna Maria Palsdottir, Swedish University of Agricultural Science, Department of People and Society

Examiner: Helena Persson Hovmalm, Swedish University of Agricultural Science, Department of Plant Breeding

Credits: 30 credits

Level: Second cycle, A2E

Course title: Independent Project in Agricultural Science

Course code: EX0848

Programme/education: Agroecology Master's programme

Course coordinating dept: Department of Biosystems and Technology

Place of publication: Alnarp

Year of publication: 2023

Swedish University of Agricultural Sciences

Faculty of Landscape Architecture, Horticulture, and Crop Production Science

Department of Biosystems and Technology

Acknowledgments

First, I would like to thank all the students who wanted to participate in this study and share their perceptions of GMOs. Without them, this study would not have been made possible. I would also like to thank the administrators of the agroecology, horticultural science, and land master's program for help in reaching out to students about this study.

Furthermore, I would also like to thank my supervisor Anna Maria Palsdottir for all the support and guidance during the work on this thesis. Finally, I would like to thank my family and others for the love and support they have provided through the process's ups and downs.

Abstract

Producing enough food for the world's growing population is a challenge that puts great pressure on the agricultural food system to ensure global food security. Furthermore, climate change is additionally exacerbating this challenge. Part of the solution could be genetically modified organisms (GMOs), but their use has been a source of controversy among various actors that have hindered their adoption. However, the adoption of GMOs is also linked to acceptance by the general public, hence making it important to examine their perceptions of GMOs. Therefore, this study aimed to examine students' perceptions of GMOs to understand what is required to increase the acceptance of GMOs.

This was carried out through qualitative semi-structured interviews with students enrolled at the Swedish University of Agriculture and a qualitative content analysis of the student's perceptions. The results of the study show, among other things, that there are both similarities and differences between the participating students' perceptions of GMOs. Furthermore, the results also show that some participating students' perceptions are more constructed around values and ethics than others. Therefore, a conclusion that can be drawn from the results is that a good knowledge of GMOs may not lead to a higher acceptance of the technology. Furthermore, the results indicate that what may be required to increase acceptance is a focus on tailored information and targeted communication styles.

Keywords: Genetically modified organisms, perceptions, acceptance, students, qualitative semi-structured interviews

Table of contents

1. Introduction	7
1.1 Genetically modified organisms	8
1.2 Public perceptions of GMOs	9
1.3 Actions to increase the acceptability of GMOs	11
2. Objectives	13
2.1 Purpose	13
2.2 Research Questions	13
3. Methodology	14
3.1 Data gathering	14
3.1.1 Informants	14
3.1.2 Qualitative semi-structured interviews	15
3.1.3 The interviews	15
3.1.4 Transcription	16
3.2 Data analysis	16
3.2.1 Qualitative content analysis	16
3.2.2 Analysis of the gathered data	17
3.3 Research quality	17
3.3.1 Credibility	17
3.3.2 Dependability	18
3.3.3 Transferability	18
3.3.4 Confirmability	18
3.4 Ethics	19
4. Results	20
4.1 Different views on the technology	20
4.2 Traits	21
4.3 Consumption	22
4.4 Knowledge and information	22
4.5 Corporate control	24
4.6 Another way	25
5. Discussion	27
5.1 Result discussion	27
5.1.1 Perceptions	27
5.1.1.1 Similarities	27
5.1.1.2 Differences	29
5.1.2 Acceptance	31
5.2 Methodology discussion	33
6. Concluding remarks and suggestions for further research	35

References	36
Appendix 1	41

1. Introduction

Producing sufficient food for a growing population is a challenge that has not yet been overcome (Qaim 2020) and according to Om et al. (2017), it is estimated that the global population will reach nine billion people by 2049. This puts a lot of pressure on the agricultural food system to ensure food security in the world (Malhi et al. 2021; Spendrup et al. 2021).

Food security exists when all people of the world have access to safe, sufficient, and nutritious food (The World Bank 2023). But according to Qaim and Kouser (2013:1), “food security does not exist for a significant proportion of the world population”. Instead, the number of people suffering from food insecurity has increased since 2014, and by 2020 between 720 and 811 million people worldwide were suffering from hunger. Further, it was estimated in 2020 that around 2.4 billion people were food insecure, lacking access to sufficient food (Food and Agriculture Organization of United Nations 2021). Eradicating hunger is a part of the Sustainable Development Goal 2 but as for now, one is not on track to meet this goal. And with a growing population, this raises the question of how one can meet this goal and feed the world's growing population in a sustainable way (Qaim & Kouser 2013; Oliver 2014).

In addition to a growing population, climate change further exacerbates the challenge of securing food for the world's population (Malhi et al. 2021; Mahapatra et al. 2021). This is because the agricultural sector is particularly vulnerable to weather parameters (Malhi et al. 2021), which therefore makes climate change a major threat to the agricultural sector worldwide (Kogo et al. 2021). And even if uncertainties remain regarding future climate scenarios (Malhi et al. 2021) and Kogo et al. (2021) state that it's likely that climate change will reduce agricultural productivity and cropping patterns in the near future. This is because rising temperatures, changing weather conditions, and precipitation have drastically impacted soil fertility, irrigation resources, pests, and plant's metabolic activities (Malhi et al. 2021; Mukhopadhyay et al. 2021). Pests can, according to Skendžić et al. (2021), for example, be impacted by changing weather conditions in several different ways, which can result in an increased number of pests and change the interaction between plants and pests. This could then additionally challenge food security in the world. Further, climate change's impact on agriculture will, according to Mahapatra et al. (2021) and Trivedi et al. (2016) ultimately lead to a food crisis affecting both the quantity and quality of food production.

Considering the challenges facing the agricultural food system to sustainably secure food for the world's growing population, genetically modified organisms (GMOs)

could play an important role (Qaim 2020; Spendrup et al. 2021; Oliver 2014; Kovak et al. 2022).

1.1 Genetically modified organisms

Humans have been improving crops for thousands of years using traditional breeding techniques, such as crossing and selective breeding (Phillips 2008). These techniques have been used to select crops with desired characteristics to develop new and more beneficial crop varieties. And by specific selection of characteristics, humans have been able to breed crops with desirable traits for centuries (Chassy 2007; Qaim 2020). But improving crops through traditional plant breeding techniques can take a long time and is limited to naturally occurring variations. It's also difficult to make very specific changes to crops using these techniques (Phillips 2008). But in the 1970s scientists developed a way to modify crops faster and more precisely, which opened new possibilities. This process is called genetic engineering, which produces genetically modified organisms (GMOs) (Qaim 2020; Zhang 2016). Genetically modified organisms (GMOs) are by the World Health Organization (WHO) defined as follows:

...organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, e.g. through the introduction of a gene from a different organism (World health organization 2022).

Meaning that genetic engineering allows for the transfer of a selected gene linked to a desired trait from one organism to another, usually between unrelated species (Zhang 2016; Millstone & Lang 2008; World health organization 2022) or to specifically modify a gene already existent in the organism, e.g. by the CrisprCas technique (Noman et al. 2016). This is done by transferring the gene with the desired trait into the plant cell and these cells are then grown in tissue culture where they develop into a crop. The seeds that are produced from this plant will then inherit the desired trait (Harvard University 2015). By using genetic engineering, it is, therefore, possible to develop desired traits that were previously difficult or impossible to obtain (Qaim 2020).

The most common trait identified in available GM crops is resistance to biotic stresses, such as pathogens, weeds, and insects. In general, GM crops possessing this trait can in practice help to reduce yield losses by protecting the yield that would otherwise be lost due to biotic stresses (Azadi et al. 2015). Other applications of genetic engineering are also the development of GM crops with higher resistance to abiotic stresses such as flooding, drought, heat, and soil salinity (Trivedi et al. 2016; World Health Organization 2022). In addition, genetic engineering has also

been used to develop GM crops with improved nutritional content. This application could be of particular use to help populations that lack certain nutrients. An example of this is golden rice which contains increased levels of vitamin A developed by scientists as a solution to reduce death and disease caused by vitamin A deficiency (Qaim 2020; Klein & Gordon 2022).

But since their introduction GM crops have been a source of controversy and under continuous debate which has hampered their adoption (Spendrup et al. 2021; Lukanda et al. 2023). The key actors in the debate are often Non-government organizations (NGOs), governments, scientists, journalists, biotechnologists, and companies (Lukanda et al. 2023). Those who are in favor of this technology refer to the possibility and efficiency of developing crops resistant to abiotic or biotic stresses, and improved consumer-oriented quality characteristics like nutrient content or longer shelf life (Spendrup et al. 2021). In addition to this, the proponents also point to the positive effects on health and the environment as well as increased productivity and profit as advantages of this technology (Azadi et al. 2015; Kovak et al. 2022). Further, some proponents also see GM crops as one of many solutions to reduce hunger (Qaim & Kouser 2013). For those critical of this technology, the focus has been chiefly on two areas, namely human safety and the impact on the environment (Qaim 2020; Oliver 2014). Concerns regarding human safety are connected to allergic reactions, changes in nutritional qualities, damage to organs, gene transfer, and side effects due to toxicity (Blagoevska et al. 2021; Azadi et al. 2015; Raman 2017). Meanwhile, the environmental impact concerns are connected to biodiversity loss, gene flow, forming of super pests and weeds, and the emergence of new diseases (Baltas et al. 2007; Trivedi et al. 2016). Apart from this, some have also raised concerns that GM crops could pose a potential risk to future food security, due to corporate control (Qaim & Kouser 2013). However, the adoption of GMOs is according to Rathod and Hedao (2022) also connected to public GM acceptance.

1.2 Public perceptions of GMOs

Much research has been conducted over the years on GMOs and the public's perceptions since it's a critical parameter that greatly influences the acceptance of GMOs (Twardowski et al. 2022; Woźniak et al. 2021). The acceptance of GMOs by the public differs between geographical regions, where Europeans tend to show the strongest negative perception towards GMOs (Sikora & Rzymiski 2021). However, the Eurobarometer does display an increased acceptance among the European public (Ichim 2020). Further, the public in Asia, Latin- and North America tends to show a low negative perception of GMOs. In Asia, however, the number of the public that is showing a negative view has risen. This is a result of an increased discussion around GMOs (Sikora & Rzymiski 2021).

The research that has been conducted on GMOs and the perceptions of the public examines different perspectives. Some of the research studies have focused on the impact one's surroundings and social media can have on people's perception of GMOs (Brosig & Bavorova 2019; Kim & Fang 2020). Others have concentrated on the values and beliefs behind these perceptions (Twardowski et al. 2022). Comparing research studies have also been conducted between genetic engineering and other plant breeding methods to see the differences between the acceptance of the technologies (Spendrup et al. 2021). Some studies have also focused on analyzing public acceptance of GMOs over time (Sikora & Rzymiski 2021). Apart from this research studies have also been conducted on specific groups of the public such as university students enrolled in agricultural studies or life sciences (Bulut & Ercim 2019; Om et al. 2017; Rathod & Hedao 2022). The most common methods used in these research studies to collect data for examining the public perceptions and acceptance of GMOs are questionnaires or reviews of previous research and surveys.

The results from some of the research that has been conducted indicate that men appear to have a more positive perception of GMOs than women (Spendrup et al. 2021). This can according to Spendrup et al. (2021) be because women think of GMOs as less moral if compared to other agriculture production techniques. This is coherent with a study conducted by Bredahl (2001) that concluded that there is a correlation between consumer perceptions of GMOs and how they view nature and technology in general. This since these views often tend to function as a filter for the formation of their perceptions of GMOs (Bredahl (2001). Research also indicates that young consumers tend to show a more positive attitude toward GMOs compared to old consumers (Spendrup et al. 2021). Further, a positive perception of GMOs among consumers can often be shown when one is aware of the possible benefits of this technology and when they are highlighted (Spendrup et al. 2021). However, a positive perception can also be seen when the benefits outweigh the risks and when there is trust in researchers and their results (Kim & Fang 2020; Brosig & Bavorova 2019; Twardowski et al. 2022). The advantages that consumers point out with GMOs are the longer shelf life of products, resistance to abiotic or biotic stresses, as well as the use of fewer environmental resources. Apart from this some consumers also view GMOs as a possible approach to tackle hunger, and the global challenges the food system is facing (Faccio & Fovino 2019; Palmieria et al. 2020).

When consumers show a negative perception of GMOs, it can according to Palmieria et al. (2020) be a result of a lack of knowledge of the science behind GMOs. But it can also be a result of what is being spread through media regarding

this technology (Rose et al. 2020). Among consumers that have a more negative perception of GMOs, one often points to moral concerns, risks, safety, unnatural, not compatible with religious beliefs, unpredictability, harm to the environment and health, food safety, and scientific consensus of GMOs. (Kim & Fang 2020; Palmieria et al. 2020; Twardowski et al. 2022; Faccio & Fovino 2019). According to Kim, and Fang (2020) the reason why consumers often cite risk as a disadvantage can be because risks are associated with the unknown. This in turn can be linked to resistance and rejection of GMOs. However, according to Twardowski et al. (2022), rejection of GMOs can also occur when consumers view GMOs as unnatural or incompatible with religious beliefs. Further consumers also often mention uncertainty as a disadvantage, which according to Brosig and Bavorova (2019) can be linked to the long-term effects the technology could have on the environment and human health.

Research studies conducted on specific groups of the public such as university students enrolled in agricultural studies or life sciences showed different and similar results. One study examining agricultural students' attitudes towards GMOs indicated that more than half of the participating students saw GMOs as a risk to all living creatures. But also, several of the students rejected GMOs as a solution for resolving hunger in the world. A positive perception among the students was in this study found in connection to GMOs and the possibility of extending the shelf life of products (Bulut & Ercim 2019). In a study conducted by Rathod and Hedao (2022) examining students enrolled in life science studies a high percentage of participating students had a positive perception of GMOs. Students were also found to support GMOs in connection to enriching crops' nutrient content. Most students in this study additionally agreed that the public has little awareness of GMOs. This is similar to another study that examined university students enrolled in agriculture studies showing that a majority of the students had a positive perception of GMOs. In this study, researchers (Om et al. 2017:11) also concluded that a high percentage of students are "unaware of the importance of GMOs in the modern world", but that most of the students had a good understanding of the effects of GMOs on people and the environment.

1.3 Actions to increase the acceptability of GMOs

The research that has been conducted on GMOs and the perceptions of the public points to several different actions that can be taken to increase the acceptance of GMOs among consumers. An important step to take according to Sikora and Rzymiski (2021) is that researchers need to communicate with the media to a much larger extent of their findings. This is because the media is the main communicator to the public and it is therefore important that this sector is well informed. A well-

informed media can also lead to a well-informed public that is more likely to accept and support research on GMOs (Sikora & Rzymiski 2021; Woźniak et al. 2021).

Research also points to the need for more education, for example, implementing evidence-based educational programs or supporting the ones that are already in place (Sikora & Rzymiski 2021). According to Sikora and Rzymiski (2021), this could then lead to an increase in the acceptance and awareness of GMOs. More education is also mentioned by Rathod and Hedao (2022) that point out the importance of incorporating GMOs into the curriculum for university students enrolled in agriculture or life science studies. This could then lead to a greater awareness among the students of the surrounding issues.

But Landrum et al. (2018) mean that more education directed at for example the safety of GMOs does not appear to change the perceptions consumers might have, especially in the short term. Further, Scholderer and Frewer (2003) point out that the education strategies that have been applied have not led to a change in consumers' perception and acceptance of GMOs. This could mean that the perceptions of consumers are constructed more around values, ethics, and social dimensions. Therefore, future studies should concentrate more on the social dimension where perceptions of GMOs are constructed to better understand how to increase the acceptance of GMOs (Scholderer & Frewer 2003). Elevated acceptance can also be reached through labeling since consumers want to know more about the methods used to produce the product. But this should be done with caution and a well-planned campaign that gives consumers the needed information about these products (Twardowski et al. 2022).

2. Objectives

In this chapter, the purpose and research questions of this study will be presented.

2.1 Purpose

As the general public's perceptions of GMOs are a critical parameter for their acceptance it remains important to further monitor and gain an understanding of the general public's perceptions. This is so that one can fully utilize the potential of this technology (Twardowski et al. 2022; Woźniak et al. 2021; Stein 2015). Furthermore, it is also important to investigate what is required to increase the acceptance of GMOs. This since a low acceptance in some countries can according to Stein (2015:9) have "consequences for developing countries that cannot afford to selectively avoid applications of modern technology in agriculture". This as it can mean that farmers in these countries are denied access to modern agricultural technology such as GMOs. As Stein (2015:5) states:

...indifference and complacency about GM food are borne by those who can least afford to do so, i.e. by smallholders and consumers in poor countries who lose the opportunity to realize the benefits that current and future GM crops could bring them and help them improve their livelihoods.

Therefore, this study aimed to examine what perceptions students enrolled at the Swedish University of Agriculture have about GMOs in order to understand what is required to increase the acceptance of GMOs.

2.2 Research Questions

The following three research questions were examined in this study:

- What is the student's perception of GMOs?
- Are there similarities and differences between the student's perceptions of GMOs?
- What is required to increase the acceptance of GMOs?

3. Methodology

This chapter will start with a presentation of the method used to gather the material followed by a section on how the material was analyzed. The chapter will then end with a section on research quality and ethics.

3.1 Data gathering

This section will start with a presentation of the informants and the method used to conduct the interviews followed by a description of how the interviews were conducted and transcribed.

3.1.1 Informants

For this study, the decision was made to only interview students at the Swedish University of Agriculture, a decision that was based on the following two factors; Firstly, this group can be considered to have an equivalent knowledge level of the subject aimed to be investigated, which could make it easier to compare the answers of the informants. Secondly, students undertaking studies in agriculture can be considered future experts in this field. Therefore, it is interesting to gain knowledge of their perceptions regarding GMOs.

To get in touch with students, a request was sent to the administrators of the agroecology, horticultural science, and land master's program for help in reaching out to students about the study. The selected programs were chosen because they had a connection to the topic in question or because there was a connection between agriculture and the food system within the program. However, it should be noted that students who only attended single courses within these programs also received information about the study.

The students were contacted in two different ways, during a period of two months about participation in this study. The program administrator contacted the students via the platform canvas, and I reached out to the students via email. The same information was conveyed in both cases about the study and its purpose. Information was also provided on how to get in touch with me if interested in taking part in the study. Those who showed interest in participation were sent information about where and when the interview would be conducted.

In total three female and three male students between the ages of 20 - 50 were interviewed. Most of the students came from Europe and were conducting studies in either the agroecology, food and landscape or horticulture program at the Swedish University of Agriculture.

3.1.2 Qualitative semi-structured interviews

When deciding what method to use to gather the material for this study it was important that the chosen method had an open approach, that would allow the informants to express their views freely. This since the aim of the study was to get an understanding of the informant's perception of GMOs. Therefore, qualitative semi-structured interviews with open-ended questions were chosen.

According to Bryman (2012), open-ended questions offer the flexibility to ask follow-up questions, which then gives both the informant and the interviewer the possibility to explore topics that might occur during the interview more deeply. However, Grönmo (2006) writes that by asking follow-up questions one might also affect the informants' answers. This since the informant might feel that there is a correct answer to give or by asking direct questions, which in return can lead to research bias. Despite this Kvale and Brinkmann (2015) mean that follow-up questions are also a strength since it gives the interviewer the ability to confirm the answers of the informant.

Further, it should be noted that the chosen method is depending on how the informants perceive their lifeworld. Meaning that their worldview is shaped by opinions gained by experience and situations in their life (Kvale & Brinkmann 2015). Therefore, it is important to have this in mind when interpreting the results of this study, since it is a question of subjectivity (Grönmo 2006).

3.1.3 The interviews

The interviews were conducted between the 10th of November and the 16 of December 2022 and were between 15-40 minutes long. Five of the interviews took place at the Swedish University of Agriculture at Campus Alnarp and one over Zoom due to sickness.

Before starting the interviews, the informants were briefed about the aim of the study and that the collected data would be used in an anonymous form. Permission was also obtained to record the interviews. The interviews were conducted in English and during all the interviews an interview guide (appendix 1) was used to make sure that certain topics were covered. The interview guide consisted of 12 open-ended predetermined questions that were asked to all the informants in the same order. Depending on the informant's answer to a question, a follow-up question was asked to further explore their answer or confirm it. If an informant did not understand a question, it was repeated or explained in more detail. All interviews ended with a debriefing where the informants were asked if there were any aspects they consider important to discuss that were not explored during the

interview. The informants were also thanked for their time and willingness to participate in this study.

When an interview had been conducted notes were taken on how the interview had been carried out and the interview situation. This is to note if something might have affected the results of the interview.

3.1.4 Transcription

The transcription of the interviews was made in a non-verbatim transcription approach, meaning that sounds like mh, hm and emotional expressions like pauses and laughter were not included (Kvale & Brinkmann 2015). The interviews were transcribed directly after they had been conducted, to detect certain themes that might have occurred during the interviews. According to Bryman (2012), this then allows one to be aware of these themes when conducting other interviews.

When transcribing the interviews, the audio recording was listened to thoroughly and pauses were taken in order to be able to write down the spoken words of the informant. Once the spoken words had been written down the sequence was listened to again before continuing the transcription. In some of the interviews hearing all the spoken words was difficult, therefore the specific sequences of the audio recording were played multiple times. In some cases, the audio recording was also slowed down to be able to identify the correct word. When the transcription of the whole interview was done, the audio recording was listened to from the beginning to ensure that the correct words had been written down. If it was detected that a word had been written down incorrectly it was corrected.

3.2 Data analysis

In this chapter, the method that was used to analyze the material from the interviews will be presented, as well as how the analysis was carried out.

3.2.1 Qualitative content analysis

To analyze the collected data from the interviews, qualitative content analysis was chosen as the analytic method. This method was chosen since the aim was not to measure or count anything but to get a deeper understanding of what the content in the gathered material expressed (Boreus & Bergström 2018).

The method was also chosen since it according to Grönmo (2006) allows one to examine the material from a certain perspective, which in this analysis meant the predetermined theme perception. This theme was chosen as a lens for the analysis based on what was aimed to be examined in this study. Apart from serving as a lens

for the analysis one's predetermined theme also helps to systematically thematize and categorize the material (Bryman 2012).

However, the use of a predetermined theme when categorizing the material can mean that interesting perspectives might be overlooked as a result of subjectivity (Grönmo 2006). This since I'm the one who categorizes the material. Therefore, it is important to keep this in mind when reading the results of the analysis.

3.2.2 Analysis of the gathered data

Before starting the analysis, the transcribed material gained from the interviews was read separately several times. This is to get an overview and to make a summary of the transcribed material from each of the interviews. Once this was done, the material from each interview was read using the leans perception. When an interesting statement was detected, it was marked using an underlining pen.

In the next step, the marked parts were extracted from the text, read through, and coded into a name. The marked parts in all of the interviews were then sorted into themes with the help of the coded names. When the material had been sorted into themes, the transcribed material was read one more time to see if any more parts of the material could be included in the themes. After this, connections and patterns were made between the different informant's statements within the themes. The different themes were then written up and if a statement that represented the theme was found it was used as a quotation. And to be able to identify the quotations used from the transcribed material it was given a reference number. This so that one could be able to trace it back to the transcribed material.

3.3 Research quality

When one undertakes a research study it's important to evaluate reliability and validity to assess the quality of the research. According to Bryman (2012), reliability and validity in a traditional way are hard to reach in qualitative research. Therefore, one should instead reflect on the research quality through the following four criteria of trustworthiness: credibility, dependability, transferability, and confirmability.

3.3.1 Credibility

Lincoln and Guba (1985) write that credibility is connected to inner validity, which is related to how true and accurate one's findings are to what was aimed to be examined. The two most common methods for promoting credibility are confirmation from the informants and triangulation (Bryman 2012). In this study, none of these methods were used which may lower the overall credibility.

However, other measures have been taken to strengthen the credibility of this study. For example, the research questions were open-ended, which can help to avoid potential bias from the interviewer. Follow-up questions were also used during the interviews to confirm the answer of the informant or to make sure that the interpretation of the informant's answer was correct. And during the transcription, steps were taken to ensure that the correct words were written down.

Further, it should be noted that according to Gomm (2008), the question of credibility is highly subjective. This since the judgment of credibility is depending on individual judgment both from the researcher and the reader of this study.

3.3.2 Dependability

This criterion is connected to if this study can be replicated by other researchers. In practice, this means that researchers attempting the same study should also reach similar results (Bryman 2012). According to Lincoln and Guba (1985), this can be achieved with a detailed description of the research process. Therefore, the researcher should be able to claim a certain level of dependability through a detailed description in the method section of the various steps in this study.

Another way to ensure dependability is according to Bryman (2012) to use an inquiry audit, which was done in this case. An inquiry auditor is a person that reviews the process of this study to make sure that other researchers could repeat it. In this case, the inquiry auditing consisted of my supervisor, students, friends, and family.

3.3.3 Transferability

Transferability is related to how well this study can be applied to similar situations or contexts, which is dependent on a dense description of the research process (Bryman 2012). To achieve this the different steps in the research process have therefore been described as detailed as possible. This is without jeopardizing the anonymity of the informants. However, Stahl and King (2020:27) write that qualitative research “does not often aim for replicability” or generalization. This is because a qualitative study like this often is smaller in size compared to a quantitative study. Bryman (2012) also writes that transferability is usually subjected to the judgment of the reader.

3.3.4 Confirmability

Bryman (2012) writes that confirmability is linked to the neutrality of the research study's results. This means that a researcher should not have influenced the research with personal opinions and assumptions. In qualitative research, complete

objectivity can according to Bryman (2012) be hard to reach. This since the researchers pre-understanding of the subject examined can affect the analysis and the results of this study.

However, to raise the level of confirmability Lincoln and Guba (1985) write that one can use an audit trail, which in this study was achieved by a detailed description of the data analysis. Apart from this, an inquiry auditor was used throughout the research process, which can contribute to raising the overall level of confirmability.

3.4 Ethics

When conducting research, it's important to consider some ethical aspects. The main aspects to consider are connected to participation, consent, anonymity, and confidentiality (Bryman 2012: Kvale & Brinkmann 2015). Participation in a study should always be voluntary, therefore the participating informants could at any point withdraw their participation in this study. All the informants were also informed about the purpose of the study before consenting to conduct an interview and how the material would be used. Permission was also obtained, from the informants, to record the interviews.

It's also important when conducting research to keep the anonymity of the participating informants. Therefore, no personally identifiable data was collected, and the informants were anonymized before the analyze was conducted of the transcribed material. All the informants were also thanked for their time and willingness to participate in this study.

4. Results

In this chapter, the results from the qualitative content analysis regarding the student's perceptions of GMOs will be presented in the following 6 themes: different views on the technology, traits, consumption, knowledge and information, corporate control, and another way.

4.1 Different views on the technology

The students that participated in this study have different views on GMOs regarding the technique and process behind the creation of GMOs. Some students view GMOs as unnatural and have similar or different explanations as to why they have this view of GMOs. One of the students says that it's no longer natural when one has added something that otherwise would not be part of the plant's genome. And says that natural is when different traits evolve naturally through recombination and mutations. And further explains that ecosystems, in general, are such balanced systems, and adding a GMO that has a specific trait that wouldn't occur naturally might be okay in the short term. But expresses a concern that no one really knows what can happen in the long run when GMOs are introduced to our ecosystems. This explanation is similar to another student that also means that GMOs are not natural since one has added a gene from one plant to another. And states that GMOs are not wanted because they are not part of nature. And says that:

... through modification, we try to control nature, but that is not the right way if one wants to be sustainable.

And means that instead, one should try to live with nature and not fight it. This student also says that there is no need to produce GMOs that are not natural and that there are other methods that one can use instead of genetic engineering to tackle challenges like the increased demand for food. A different student says that there is an ethical issue with the technology and says that:

I believe that this world was created by God and I think he gave us the knowledge and wisdom to handle it right and to care about nature. I think there are several opportunities to face a problem and modifying is not a good thing, because it's modifying something that God has created. And how God made it was good.

And therefore, this student thinks it's not a good idea to modify something and make changes to the genome of the plant. But explains that breeding is okay if it's done with the same organism. Another student says that GMOs are not strange or

not natural but expresses an underrating that some people might see it differently. Some might see it as if we humans are destroying nature rather than just being a part of an ecosystem or a part of evolution. And that it's not right to change the genome of plants by modification, because by doing so we are playing God. But says that breeding is something that we have always been doing in order to develop plants with desired traits and genetic engineering it's just another way of doing it. This is also mentioned by other students that share the same view as this student on the technology behind GMOs. And it seems that for this group of students, the problem with GMOs does not lie in the technique and process of GMOs, but rather in surrounding issues that can be related to GMOs.

4.2 Traits

The students all see the potential benefits of genetic engineering as a way of creating GMO crops with specific traits which make them resistant to both biotic and abiotic stresses. A student also develops this further by explaining that because of this possibility, it is therefore a way for people to create a positive change in agriculture. Among the students there also seems to be a consensus that the possibility of developing crops with specific traits could be a solution to the challenges farmers are facing due to climate change. This is because one can alter the DNA of plants in order to develop GMO crops that can survive in different climates, which according to one student, is the main advantage of the development of this technology. And explains that in areas where drought is a problem, farmers can still grow crops due to the development of GMO crops that can survive in these conditions.

Several of the students also say that one of the benefits of genetic engineering is that one can develop crops with traits that lead to higher yields, which in turn can contribute to tackling the problem of an increased demand of food. One also recognizes the potential of developing crops with higher nutrient content like golden rice which would be beneficial for populations in certain areas that lack diversity in crops or certain foods. General improvements in yields are also mentioned by two students as a result of GMO crops that are resistant to certain pests or infections. They express that GMO crops that are resistant to pesticides could also have a positive impact on the environment since farmers are less reliant on pesticides.

But the students also express a concern that even though GMOs can come with potential benefits due to the possibility of developing crops with specific traits one is also playing a bit with the unknown. A student also raises concerns regarding crossbreeding between GMO crops and their wild form. This since it might result

in the wild form becoming more invasive due to acquiring the trait from the GMO crop.

4.3 Consumption

Among the students, there are different opinions regarding the consumption of GMOs. Some of the students regard GMOs as safe to consume since no evidence points toward the opposite and says that we are already consuming these kinds of foods. And one of the students expresses the importance to communicate this to the public since some question this. And explains that the reason that some people are sceptical or view GMOs as not safe to consume can be because they do not fully understand the science behind this technology. Another student that also regards GMOs as safe to consume expresses trust in science and the testing process of GMOs. And does therefore consider it safe to consume, but also points out that there are different opinions in research regarding this. This student also questions whether one should consume GMOs even if some claim that it is safe to do so. And states that:

we do not need GMOs to improve our diets, since we have everything that we need. And therefore, one does not need the hyper version of the food that we already have.

And means that instead, things should stay as natural as possible. This opinion is shared with other students that also expresses the importance of food being natural. One of the students means that GMO food is like industrial food and expresses the importance of consuming only real food that has been grown naturally. Another student that would not consume GMOs means that there is not enough information about the consequences of consuming GMOs. And states that it is important to know what effects this kind of food will have on our bodies and points out that it is our right to know what we are eating. And says that as of now we are not getting this kind of information which is a problem. Two of the students suggest that this kind of information could come through labeling.

4.4 Knowledge and information

One of the areas where the students seem to have the same perception about GMOs is when it comes to the knowledge of the public and what kind of information that needs to be conveyed. The students all agree that the public needs to be more educated about GMOs and that this is important to address. One of the students means that the main downfall with GMOs is that the general public isn't very educated. And says that a possible way to tackle this can be to use visual

information in the form of an information brochure that only focuses on the concept and the technique of GMOs. To focus only on the technique behind GMOs when communicating to the public is something that another student also mentions. This student explains that:

When you are talking about this technology one should try to keep it as natural as possible and just focus on what are the benefits and what are the potential downsides of it. Because when it starts to become connected to other political issues, I think that's where you start to lose people and people will start to give their views based on other issues rather than on the topic itself.

So according to this student, it is important to isolate the information about GMOs from other topics and to focus only on the concept of GMOs. And expresses the importance that the information given about GMOs is consistent and on topic. A student also said that one should include basic biology courses that include genetic engineering at an early stage in education so that people become a little more aware of this technology. This is in line with another student that also states that we need to start educating children at an earlier age about GMOs. Other students also express that in their current education, the topic of GMOs is not discussed to a large extent and if so, the information is only given on the technology behind GMOs. And what is missing, according to them, is not more education about GMOs but the actual discussion around GMOs.

Another student explains that a lot of the information, about GMOs, often comes from America which has very powerful farming lobbies and very strong agribusiness companies that do hold a lot of political influence. And this could therefore impact the information that is portrayed in the media and then conveyed to the public. When it comes to the information that is conveyed to the public another student also says that the media often portray GMOs as something negative through the information they convey, which can contribute to shaping a negative view among the public. This negative view could then limit the amount of research that can be done in this area. Therefore, it's important to also look at what the media communicate to the public about GMOs to make sure that a balanced view is portrayed. This negative view is also mentioned by another student that says:

I think most people have the view of GMOs being something bad and I think that many people when they think about GMOs, they think about Monsanto resistance patented seeds and that might be something bad but

GMOs itself is not a bad thing. It's a very nice thing to be able to make something more resilient in an environment.

And therefore, believes that the public needs to be more educated about GMOs and be provided with the information that there is a good way to do genetic modification and that there is a capitalistic way of genetic modification.

4.5 Corporate control

One of the disadvantages mentioned by some of the students in connection to GMOs is corporate control. Corporate control is by these students considered a big downside with GMOs, especially in connection to seeds since it can create a dependency. One student explains that it's a problem when GMOs are used in our capitalistic food production system to create dependencies because then the motivation is not to feed the world but to make money. The student further explains that it is also problematic when companies start patenting seeds and creating capitalistic dependencies just because the crop only grow if you use a certain herbicide. And states that this is something that should be illegal because seeds ought to be free and available for everyone to use. Another student also explains that because companies own the rights to these seeds, they often benefit from the dependency it creates at the expense of the farmers. This is because they have the money and the rights and therefore this is something that needs to be addressed. A student also means that it's not an ideal situation to have farmers purchasing GMO seeds from companies like Monsanto because they are then at their mercy. And points out that farmers that are using GMOs often have little control over what they can do, but also explains that:

Usually, farmers just buy seeds anyway so it's just really a matter of whether they have a wide enough variety and whether there is enough competition in the market for farmers to have choices of what seeds they want to sow.

So, in the end, it's about having competitive markets for seeds and giving farmers choices, which ultimately comes down to economic policy and political decisions. This student also explains that the reason why some people are worried about corporate control can be because of the effect it can have on policies and farmers. But also, since it can in return lead to the creation of monocultures and the destruction of the soil, due to over-reliance on pesticides.

4.6 Another way

Among the students, there are different opinions regarding the way forward. Some of the students mean that one needs to find other ways to deal with the problems that our food system is facing and that these should be given a higher priority before considering GMOs. This is further explained by a student who says that some people believe that GMOs are needed because of the increasing demand for food. But states that there are more suitable options one should consider instead of GMOs that are more sustainable. A good way, according to this student, could be agroforestry, precision agriculture, or agroecology. Apart from these one should also look more into food waste and the importance of planning our cultivation in order to produce more food.

Another student says that GMOs are the wrong approach when it comes to dealing with the problems our food system is facing. These problems could instead be handled by having no monocultures and using more rotation and diversity in agriculture. And according to this student GMOs might not help to prevent hunger and therefore researchers should also find other ways to deal with problems like food safety. One student also expresses that GMOs are not necessary because we already have everything that we need and therefore the focus should be on how best to use these resources.

Other students argue that GMOs may still be the way forward, but that there is a need to look at how GMOs are grown and that the main drive needs to be shifted away from profit. One student explains that there is a need for a perception shift meaning that companies need to shift the focus from wanting to make as much money as possible to instead having a focus on making farming as sustainable as possible. And states that:

I would like to have a food production system that is not profit-driven but future-driven. That means that it's not about growing annual crops year after year and trying to grow the crop that gives me the most money because the stock market provides it. But rather to invest in something that will continue for a longer time.

So instead of cultivating GMOs with profit and yields as the main driving force one could move in the direction of ecosystem services. This is a direction that has never really been considered in GMOs and is a path that this student would like to see in the future:

Companies should take this on and say okay our crop is producing high yields and it is providing ecosystem services at the same time its regenerative for the future you can grow it year after year and it's not depleting the soil it's enriching the soil it is making the entire agroecosystem more resilient and more stable.

So, if one can apply this approach GMOs could, according to this student, be an important and amazing tool for creating sustainable agriculture. Another student also expresses that there is no reason that one could not use GMO crops within an intercropping system but explained that this is not really something that is considered. And points out that the techniques mentioned within agroecology often are complicated and difficult to adopt. These approaches most often also have a big cost associated with them and using new seed varieties is an incredibly simple approach for farmers to apply. Therefore, this student means that GMOs are something that should be perused since it's something that is likely to work. But one should not see it as the perfect solution and states that one should also look at cultivating GMOs differently. According to this student, one also needs to look at reshaping the regulation, since GMOs:

...are quite expensive to get to the market it's expensive to develop them and the testing is rigorous which is costly. So, I think unless it's a really big important cash crop I think companies don't really want to invest the money in creating GMOs because they see it as risky because there is a negative perception of them in some parts of the world.

So, for companies to be able to invest in research and developing GMOs it's important to oversee the regulation but also to make it easier for the companies to sell these seeds in the European market. Because as for now companies might not be willing to invest tens of billions of dollars in developing these seeds, since they are not able to sell to the European market.

5. Discussion

This chapter begins with a discussion of the results from the qualitative content analysis, which is then followed by a method discussion.

5.1 Result discussion

In this section, the results of the qualitative content analysis regarding student perceptions of GMOs will be further discussed as well as what is required to increase the acceptance of GMOs.

5.1.1 Perceptions

This section will be divided into the following two themes: similarities and differences.

5.1.1.1 Similarities

The broader picture emerging from the result of the interviews shows that there are both similarities and differences between the participating student's perceptions of GMOs. The similarities one can see between the student's perceptions are particularly connected to topics surrounding knowledge and information, traits, and corporate control. Within these topics, the students' perspectives are more in line with each other's and there also seems to be a certain degree of consensus between most of the students.

Regarding the topic of knowledge and information, the students agree that the general public's knowledge of GMOs is low and that this is important to address. Furthermore, one also seems to agree that the information conveyed should focus on the concept and technology behind genetic engineering. The notion that the general public has little knowledge about GMOs was also found among participating students in a study conducted by Rathod and Hedao (2022). Previous research has according to Wunderlich and Gatto (2015) suggested that one's level of knowledge can impact one's views of GMOs. And as the students point out, it may therefore be important to raise the level of knowledge about GMOs among the general public. However, Kim and Fang (2020) write that an increased level of knowledge does not automatically mean that this is then reflected in one's perspective on GMOs.

Moreover, some of the students also seem to agree that media plays a role in shaping the views of the public due to the information that is conveyed. This is something

that past research has examined, and it has been noted that the general public perceptions of GMOs may have been influenced by media frames (Vigani 2017; Twardowski et al. 2022). Therefore, it can be important to make sure that an objective view is portrayed by the media. Meaning that the general public is informed of both the potential risk and benefits of this technology. However, one of the students points out that most often this is not the case. Instead, GMOs are often portrayed in a negative light by the media. This can according to Vigani (2017) be because the media companies focus on profit and therefore aim to make the news more attractive to consumers. Vigani (2017:204) further writes that “the marginal value of an item of news with negative welfare effects is higher than the marginal value of an item of news with positive welfare effects”. So, by portraying GMOs in a negative light, it could mean that the media companies can increase their profit. Due to this, it can therefore be more important to address the potential risks than the benefits of GMOs. This since they are according to Rose et al. (2020:1028) “widely discussed in the media and that raise practical concerns about the technology”.

In terms of traits, the students point out resistance to abiotic or biotic stresses as the main advantage of GMOs, which is in line with previous research (Evanega et al. 2022). One student particularly points out the potential of enriching crops’ nutrient content, which was also expressed by students in the study conducted by Rathod and Hedao (2022). But at the same time the students also express concerns regarding that one is playing a bit with the unknown. What the participating students associated with the term unknown was not identified, but the notion of the unknown can according to Kim and Fang (2020) be connected to potential risks with GMOs. These risks are often linked to the possible effects the technology can have on health and the environment, as mentioned by one of the students. Further, Pappalardo et al. (2021) write that how one judge this risk associated with GMOs can be influenced by how one’s social group perceive information on GMOs. Furthermore, Kim and Fang (2020:4) state that the notion of the unknown can also be connected to the “worry that scientists have failed to provide long-term effects of the technology”. This can then fuel the notion of the unknown since there is a concern that scientists have not formed a complete picture of the effects the technology could have on health and the environment.

When it comes to the topic of corporate control, the students who mention it agree that it is a major disadvantage of GMOs, due to the creation of dependencies. According to Evanega et al. (2022), it is not unusual for this to be mentioned as a disadvantage. This since it is one of the most cited concerns with GMOs among the general public. However, in a study conducted by Pappalardo et al. (2021), it was found that this is not only a concern among the general public but also scientists. In

this study, both the general public and scientists expressed concern that GM cultivation is concentrated around a few multinational companies. National Geographic Society (2022) explains that this concern is usually linked to the fact that these companies own the intellectual property rights for these genetic variations. Therefore, a shift to GMO crops could mean that food production is centralized around a few multinational companies. In the end, this could then pose a risk to long-term food security due to the creation of dependencies. How best to address the concern connected to corporate control is complex, but one student express that this is a question of economic policy and political decisions through which politicians and policymakers must make sure that there are competitive seed markets that give farmers choice. Further, it might also be important to inform the general public that GM crops are also produced by non-profit organizations and universities as it is less known. And even if this is done on a smaller scale, it could be beneficial to convey this information to the public (Ferdman 2015). This as it could perhaps affect the public's view of GMOs in relation to concerns about corporate control.

5.1.1.2 Differences

The differences between the students' perceptions are particularly prominent in connection to how they view this technology, consumption, and the future. Within these topics, one can see that there is a divide between the students and their perceptions. However, the students have different explanations for why they have these perceptions even if they share the same opinion on these topics.

In the results, one can see that there is a clear divide between the students and their view of the technology. Some students view GMOs as unnatural, which according to Weale (2010) is a widespread opinion. In these students' explanations, one can see a correlation between unnaturalness and the addition of a gene that otherwise would not have been a part of the selected plant's genome. Furthermore, one can also see that these students express the importance of keeping the natural order and raise concerns regarding possible effects on the ecosystem. According to Weale (2010:585), these expressions can be linked to safety and the notion that our current "biological and ecological systems are relatively robust and predictable". Therefore, the current systems are not associated with risks. But the release of GMOs into the environment could change the natural order raising the potential risks to humans and the environment. Further Weale (2010) writes that there can also be a connection between unnaturalness and religious beliefs, which is expressed by one of the students. This connection can be associated with the principle that it is morally wrong to modify nature since it is a creation of God (Gatew & Mengistu 2019).

However, as can be seen from the results, the perception of unnaturalness is not shared by all students who instead express that genetic engineering is just another form of breeding. This group of students also believes that the problem with GMOs lies in surrounding issues regarding this technology. This difference may indicate that students see nature differently, which in turn affects their view of the technology a conclusion that was also drawn in a study conducted by Bredahl (2001). In addition, it may also be because the focus for these students is on the benefits of the technology itself and what it can contribute.

Regarding the topic of consumption, it seems that among the students this is either a question of safety or naturalness. The question of safety is for some of the students, not an issue since no evidence points towards that GMO food poses a risk to human health. This is coherent with the main international and national scientific organizations that according to Twardowski et al. (2022) regard food that is produced from GMOs as safe. However, a large portion of the general public still believes that GMO food possesses a risk to human health. Kim and Fang (2020) write that this could be linked to a worry that scientists have not yet provided enough information regarding the long-term effects GMO food could have on human health. This lack of information is mentioned by one of the students that expresses that this is a problem. Consequently, this lack of information may fuel the perception of uncertainty and lead to a rejection of GMO food (Kim and Fang 2020) which is the case for this student. But it may also be because scientists have not succeeded in conveying the public that there is a consensus on the safety of GMOs (Evanega et al. 2022), which is also stated by one of the students. Furthermore, Twardowski et al. (2022) write that the reason why the public still believes that GMO food poses a risk to human health can also be linked to motivated reasoning.

But for some of the students, consumption of GMOs is more about things staying as natural as possible rather than a question of safety. For these students, it's important that the food they consume is natural. Rose et al. (2020) write that this can then be connected to the view that food that is produced in a natural way is more healthful, which is also expressed by one of the students. Further, this can according to Rose et al. (2020:1020) stem from the belief that genetic modification is a "highly unnatural process in stark contrast to food production in the natural world". So, food that is produced using genetic engineering produces products with lesser quality.

The results also show that the students have divided opinions regarding the way forward. Some of the students do not see GMOs as a part of the solution to the problems our food system is facing and instead, point out that are more sustainable

approaches one could adopt. Agroforestry, precision agriculture, and agroecology are some of the approaches that are mentioned as possible approaches one could adopt. The students that hold this view are also the ones that perceive GMOs as unnatural and that deemed that the food consumed must be natural. Meanwhile, others consider GMOs as a part of the way forward but express the need for a shift in how GMOs are currently being cultivated and that there is a need for a perception shift.

5.1.2 Acceptance

The students who participated in this study were all found to have a good knowledge of GMOs and the process behind this technology, although at different levels. A similar conclusion was drawn in a study by Om et al. (2017) where the participating students also were found to have a good knowledge of GMOs. But in this study, it was also concluded that the participating students lacked an understanding of the significance of GMOs, which was not the case in the present study. What seems to differ from other studies, however, is that the students in the present study expressed a need for more discussions around GMOs and not more education about GMOs.

However, what becomes clear when viewing the results is that a good knowledge of GMOs may not lead to a higher acceptance of the technology. As the results of this study show this is particularly clear in connection to topics like consumption and how one views the technology. Here some of the student's perceptions seem to be based more on ethics and values. This could then mean that new information and evidence about GMOs regarding these topics would still be rejected by these individuals due to motivated reasoning. A good understanding of the technology underlying genetic modification might not change once acceptance or view of GMOs which was also concluded in a study by Kim and Fang (2020). This could then support Scholderer and Frewers (2003) theory that the public's perceptions are more constructed around values, ethics, and social dimensions. Further, Twardowski et al. (2022) write that often are values and ideologies the formation of one's opinions of technologies like genetic engineering. So, it might therefore be more effective to concentrate on these aspects than on more education to better understand what is required to increase the acceptance of GMOs.

If, after all, one was to focus on increasing the acceptance of GMOs through more education, it may be important to tailor the information conveyed to the specific target groups. This since the knowledge among the general public might be at different levels due to education or other factors. But also, because values, beliefs, and ethical concerns seem to be the foundation for the formation of the general public's perceptions, as seen in this study. Moreover, it may also be important to

study how this information is conveyed and processed through different social groups. This since the information strategies that have been implemented especially in Europe according to Scholder and Frewers (2003) have not led to any major change in the public's view of GMOs. This thought is also brought up in an article by Faccio and Fovino (2019:8) who writes that one could use “communication styles tailored to the audience to maximize the effectiveness of a positive message about GMOs”. So, by tailoring the communication style one might be able to increase the acceptance of GMOs among the public.

Further, how scientist communicates their research might also be important to examine since the general public according to Twardowski et al. (2022) tends to take information shortcuts since scientific research can be difficult to understand. To some extent, this can be a contributing factor as to why the acceptance of GMOs continues to be low. This since the general public might base their perceptions on media frames and other actors since the information that is conveyed through these platforms is easier to understand.

An additional measure could be to look at what is communicated through different platforms regarding GMOs. As previous research has noted media frames regarding GMOs could influence the general public’s views (Rose et al. 2020), which also is expressed by one of the participating students in the present study. Therefore, it is important to make sure that an objective view is portrayed by the media. Here scientists could play an important role by communicating findings to a larger extent, which then according to Sikora and Rzymiski (2021) could lead to well-informed media. In turn, this could generate a well-informed public that is more likely to accept and support research on GMOs.

Further, Evanega et al. (2022:48) state that it is important for the scientific community to continue to “address the gaps between traditional and social media debates” because “the influence of negative sentiments and actors continues to weigh on det debate and skew public perceptions”. Here it becomes crucial to deal with the risks and misconceptions that are spread about GMOs via social media, which could, according to Bode et al. (2021) be corrected once they have been addressed. For example, by addressing the misperception spread by social media regarding the consensus safety of consuming GMOs Bode et al. (2021) found that people’s misunderstandings regarding this issue were reduced. Furthermore, it was also noted that this had a positive effect on misperceptions regarding GMOs in general. So further closing the gap between these platforms could mean that public perceptions of GMOs, in the end, are more based on honest scientific evidence.

Twardowski et al. (2022) also write that increased acceptance of GMOs could be reached through labeling. This since the general public wants to know more about how these products are produced, a view which is also expressed by two of the students in the present study. Kolodinsky and Lusk (2018) point out that it is unlikely that labeling GMOs will signal to the public that these products are unsafe or riskier, but instead, express that it could do the opposite. This, since the use of labels could according to Kolodinsky and Lusk (2018) increase the consumer's sense of control, which can be related to one's risk perception. By using labels, you give the general public the choice to reject the product. Therefore, they might view these products as less risky since it becomes an informed decision giving the general public a sense of control. Therefore, labeling could increase acceptance since it might lower the general public's sense of risk regarding GMOs (Kolodinsky and Lusk (2018)).

5.2 Methodology discussion

When conducting research, it's important to not only assess the quality of the research but also to reflect on the methodology. This is so that researchers wanting to replicate this study are well-informed about every aspect of this research.

The biggest obstacle encountered during this study was in connection to informants and participation. As mentioned in section 3.1.1 the students were contacted both through the platform canvas and email. But despite this, it was difficult to get enough students to participate in the study, which led to a low number of informants. Therefore, one might consider looking at other ways to contact students if wanting to replicate this study. For example, one could also reach out to students through a presentation in connection to lectures about the study and its purpose. However, it should be noted that even with a small number of participants patterns and similarities could be seen already in interview three. Another problem in connection to informants was that several interviews were canceled since informants did not attend the booked appointment. When this happened the informant in question was contacted to see if there still was an interest in participating in the study.

As mentioned in section 3.1.3 one of the interviews was conducted over Zoom and in a retro perspective, it might have been better to reschedule the interview. This is so that all the interviews would have been conducted in the same way. But also, since it might have affected the interview due to a lack of personal interaction. This since non-verbal communication was lost to some extent.

Furthermore, the choice to only interview students may have meant that other important perspectives might have been missed. This could be the perspective of

other students studying in another program, farmers, consumers, organizations, or researchers. It may therefore be interesting to include more than one perspective if wanting to replicate this study so that one can compare responses between different groups.

When transcribing the collected data from the interviews, it was noted that direct questions were asked to some of the informants, which may have led to bias. However, it was also observed that this was done to confirm the informants' answers. Important to note about the follow-up questions is also that they can be a result of the researcher's pre-understanding, rather than a direct response to the informant's answer. Though I tried to the greatest extent possible during the interviews to ensure that it was the informants' perspectives that were collected through follow-up questions.

In section 3.1.4 it was mentioned that in some of the interviews, it was difficult to hear all the spoken words. As a result, some of the words were therefore not identified, despite several attempts. However, an assessment was made that this would not affect the overall understanding of the transcribed material. This since it was not entire text sections that were not identified, but single words. Furthermore, a thorough translation of the informants' words was made in the analysis to the greatest extent possible to avoid misinterpretations. Despite this, the pre-understanding of the research topic may still have influenced the analysis of the transcribed material.

Lastly, it should be mentioned that to get in touch with students about participation in this study, gatekeepers were used in the form of administrators. The gatekeepers were given instructions on what was to be conveyed to the students about the study. Despite this one cannot fully control the interaction between the gatekeepers and the students, therefore it is important to have this in mind. However, this study would not have been possible without the help of the gatekeepers.

6. Concluding remarks and suggestions for further research

This study examined students' perceptions of GMOs to understand what is required to increase the acceptance of GMOs. And although this study is small, there are indications that there are similarities with other studies. However, it should be noted that to draw any significant conclusions, this study should be done on a larger scale.

In summary, the results of the study show that there are both similarities and differences between the participating student's perceptions of GMOs. Further, the results also show that some students base their perceptions more on ethics and values than others. This is particularly prominent when it comes to topics such as consumption and how one views this technology. What this may indicate is that a good knowledge of GMOs may not lead to a higher acceptance of the technology. Furthermore, it could also imply that new information and evidence regarding GMOs might be rejected when perceptions are more based on values and ethics due to motivated reasoning.

What may therefore be required to increase acceptance is a focus on tailored information and targeted communication styles rather than on more general knowledge about GMOs. This since both previous research and this study indicate that the general public's perceptions may be more based on values and ethics. Furthermore, researchers also need to communicate their findings to a larger extent, both to the media and the general public. Here, it also becomes important to use tailored communication styles that suit the target group. The scientific community should additionally work on closing the gap between traditional and social media. This is so that the general public perceptions of GMOs, in the end, are more based on honest scientific evidence. With these conclusions in mind, the hope is that it can contribute to the design of an information package that is more adapted to meet the public's perception of GMOs. But also, to the creation of a platform where researchers can interact with the public about one's findings in a more easily understandable language.

Based on the conclusions of this study subsequent research should further examine if tailored information and targeted communication styles could increase acceptance among the general public. However, this should be done once one has a better understanding of how values and ethics influence one's perception of GMOs. This is so that one can best adapt the information and communication style to the target group.

References

- Azadi, H., Ghanian, M., Ghoochani, O.M., Rafiaani, P., Taning, C.N.T., Hajivand, R.Y. & Gogot, T. (2015). Genetically Modified Crops: Towards Agricultural Growth, Agricultural Development, or Agricultural Sustainability?. *Food Reviews International*. 31, 195–221. <https://doi.org/10.1080/87559129.2014.994816>
- Baltas, H., Arvanitoyannis, I.S. & Varzakas, T.H. (2007). The Politics and Science Behind GMO Acceptance. *Critical Reviews in Food Science and Nutrition*. 47 (4), 335–361. <https://doi.org/10.1080/10408390600762696>
- Blagoevska, K., Ilievska, G., Jankuloski, D., Dimzoska, B. S., Crceva, R., Nikolovska. & Angeleska, A. (2021). The controversies of genetically modified food. *IOP Conference Series Earth and Environmental Science*. 854(1), 1-7. doi:10.1088/1755-1315/854/1/012009
- Bode, L., Vraga, E.K. & Tully, M. (2021). Correcting Misperceptions About Genetically Modified Food on social media: Examining the Impact of Experts, Social Media Heuristics, and the Gateway Belief Model. *Science communication*. 43 (2), 225-251. <https://doi.org/10.1177/1075547020981375>
- Boreus, K. & Bergström, G. (2018). *Textens mening och makt – metod i samhällsvetenskaplig text och diskursanalys*. Studentlitteratur AB: Lund.
- Bredahl, L. (2001). Determination of consumer attitudes and purchase intentions with regard to genetically modified foods – results of a cross-national survey. *Journal of Consumer Policy*. 24, 23–61.
- Brosig, s. & Bavorova, M. (2019). Association of attitudes towards genetically modified food among young adults and their referent persons. *PLoS ONE*. 14(2), 1-19. <https://doi.org/10.1371/journal.pone.0211879>
- Bryman, A. (2012). *Social research methods*. New York: Oxford University Press.
- Bulut, A. & Ercim, R.E. (2019). Agriculture faculty students' knowledge, attitude, and behaviors about genetically modified organisms (GMOs). *Annals of Medical Research*. 26(11), 2562-7.
- Chassy, B. (2007). The history and future of GMOs in food and agriculture. *Cereal foods world*. 52 (4), 169-172. doi:10.1094/CFW-52-4-0169
- Evanega, S., Conrowa, J., Adams, J. & Lynas, M. (2022). The state of the 'GMO' debate - toward an increasingly favorable and less polarized media conversation on ag-biotech?. *GM crops and Food*. 13 (1), 38-49. <https://doi.org/10.1080/21645698.2022.2051243>
- Faccio, E. & Fovino, L.G.N. (2019). Food Neophobia or Distrust of Novelties? Exploring Consumers' Attitudes toward GMOs, Insects and Cultured Meat. *Applied science*. 9(20), 1-16. <https://doi.org/10.3390/app9204440>
- Ferdman, R.A. (2015). *Why we're so scared of GMOs, according to someone who has studied them since the start*. <https://www.washingtonpost.com/news/wonk/wp/2015/07/06/why-people->

are-so-scared-of-gmos-according-to-someone-who-has-studied-the-fear-since-the-start/ [2023-04-27]

- Food and Agriculture Organization of United Nations (2021). *State of Food Security and Nutrition in the World 2021*. (The state of the world, SOFI 2021). Rome: Food and agriculture organization of united nations. <https://www.fao.org/3/cb4474en/cb4474en.pdf>
- Gatew, H. & Mengistu, K.(2019). Genetically modified foods (GMOs); a review of genetic engineering. *Journal of Life Science and Biomedicine*. 9 (6), 157-163.
- Gomm, R. (2008). *Social Research Methodology - A critical Introduction*. NewYork: Palgrave Macmillan.
- Grönmo, S. (2006). *Metoder i samhällsvetenskap*. Liber AB: Malmö.
- Harvard University (2015). *How to make a gmo*. <https://sitn.hms.harvard.edu/flash/2015/how-to-make-a-gmo/>. [2022-12-14]
- Ichim, M.C. (2020). The more favorable attitude of the citizens toward GMOs supports a new regulatory framework in the European Union. *GM crops and food*. 12 (1), 18- 24. <https://doi.org/10.1080/21645698.2020.1795525>
- Kim, J. & Fang, S. (2020). Decisions to choose genetically modified foods: how do people’s perceptions of science and scientists affect their choices?. *Journal of Science Communication*. 19(2), 1-20. <https://doi.org/10.22323/2.19020201>
- Klein, M. & Gordon, C. (2022). Changing public opinions on genetically modified organisms through access to education resources. *Journal of emerging investigators*. 5(1), 1-3.
- Kogo, B.K, Kumar, L. & Koech, R.(2021). Climate change and variability in Kenya: a review of impacts on agriculture and food security. *Environment, Development and Sustainability*. 23, 23-43. <https://doi.org/10.1007/s10668-020-00589-1>
- Kolodinsky, J. & Lusk, J.L. (2018). Mandatory labels can improve attitudes toward genetically engineered food. *Science advances*. 4 (6), 1-5. <https://doi.org/10.1126/sciadv.aag1413>
- Kovak, E., Rejto, D.B. & Qaim, M.(2022). Genetically modified crops support climate change mitigation. *Trends in Plant Science*. 27 (7), 627-629. <https://doi.org/10.1016/j.tplants.2022.01.004>
- Kvale, S. & Brinkmann, S. (2015). *Interviews: learning the craft of qualitative research interviewing*. California: Sage Publications.
- Landrum, A.R., Hallman, W,K. & Jamieson, K.H. (2018). Examining the Impact of Expert Voices: Communicating the Scientific Consensus on Genetically-modified Organisms. *Environmental communication*. 13(1), 51-70. <https://doi.org/10.1080/17524032.2018.1502201>
- Lincoln, Y. S. & Guba E. G.(1985). *Naturalistic Inquiry*. California: SAGE Publications Inc.

- Lukanda, I.N., Kaale, S.N. & Claassen, G. (2023). Media as mediators in a science-based issue: politics, foreign influence and implications on adoption of Genetically Modified Organisms in food production in Uganda. *Journal of Science Communication*. 22 (01), 1-22. <https://doi.org/10.22323/2.22010203>
- Mahapatra, B., Walia, M., Rao, C.A.R., Raju, B.M.K. & Suggurti, N. (2021). Vulnerability of agriculture to climate change increases the risk of child malnutrition: Evidence from a large-scale observational study in India. *Plos one*. 16 (6), 1-15. <https://doi.org/10.1371/journal.pone.0253637>
- Malhi, G.S., Kaur, M. & Kaushik, P. (2021). Impact of Climate Change on Agriculture and Its Mitigation Strategies: A Review. *Sustainability*. 13 (3), 1-21. <https://doi.org/10.3390/su13031318>
- Millstone, E. & Lang, T. (2008). *The Atlas of Food Who Eats What, Where, and Why*. United Kingdom: Earthscan.
- Mukhopadhyay, R., Sakar, B., Jat, H.S., Sharma, P.C. & Bolan, N.S. (2021). Soil salinity under climate change: Challenges for sustainable agriculture and food security. *Journal of Environmental Management*. 280 (15), 1-14. <https://doi.org/10.1016/j.jenvman.2020.111736>
- National Geographic Society (2022). *Are Genetically Modified Crops the Answer to World Hunger?* [https://education.nationalgeographic.org/resource/are-genetically-modified-crops-answer-world-hunger/\[2023-03-20\]](https://education.nationalgeographic.org/resource/are-genetically-modified-crops-answer-world-hunger/[2023-03-20])
- Noman, A., Aqeel, M. & He, S. (2016). CRISPR-Cas9: Tool for Qualitative and Quantitative Plant Genome Editing. *Frontiers in Plant Science*. 7(1740), 1-17. <https://doi.org/10.3389/fpls.2016.01740>
- Oliver, M.J. (2014). Why We Need GMO Crops in Agriculture. *Missouri Medicine*. 111(6), 492–507.
- Om, J., Chimhungwe, M., Singh, A.S. & Tesema, M. W. (2017). The Opinion Regarding Genetically Modified Organisms among the University Students of Agriculture in Swaziland. *International Journal of Research in Engineering*. 7 (7), 1-11.
- Palmieria, N., Simeoneb, M., Russoc, C. & Peritod, M.A. (2020). Profiling young consumers' perceptions of GMO products: A case study on Italian undergraduate students. *International Journal of Gastronomy and Food Science*. 21, 1-7. <https://doi.org/10.1016/j.ijgfs.2020.100224>
- Pappalardo, G., D'Amico, M. & Lusk, J.L. (2021). Comparing the views of the Italian general public and scientists on GMOs. *International Journal of Food Science and Technology*. 56(7), 3641–3650.
- Phillips, T. (2008). Genetically modified organisms (GMOs): Transgenic crops and recombinant DNA technology. *Nature Education*. 1(1), 213.
- Qaim, M. (2020). Role of new plant breeding technologies for food security and sustainable agriculture development. *Applied economic perspectives and policy*. 42 (2), 129-150. <https://doi.org/10.1002/aep.13044>
- Qaim, M. & Kouser, S. (2013). Genetically Modified Crops and Food Security. *PLoS ONE*. 8 (6), 1-7. <https://doi.org/10.1371/journal.pone.0064879>

- Raman, R. (2017). The impact of Genetically Modified (GM) crops in modern agriculture: A review. *GM Crops & Food*. 8 (4), 195–208. <https://doi.org/10.1080/21645698.2017.1413522>
- Rathod, D. & Hedaoo, R.P. (2022). Assessment of Knowledge and Attitudes on Genetically Modified Foods Among Students Studying Life Sciences. *Cureus*. 14 (12), 1-9.
- Rose, K.M., Brossard, D. & Scheufele, D.A. (2020). Of Society, Nature, and Health: How Perceptions of Specific Risks and Benefits of Genetically Engineered Foods Shape Public Rejection. *Environmental communication*. 14(7), 1017–1031. <https://doi.org/10.1080/17524032.2019.1710227>
- Scholderer, J. & Frewer, L.J. (2003). The biotechnology communication paradox: Experimental evidence and the need for a new strategy. *Journal of consumer policy*. 26, 125–127.
- Sikora, D. & Rzymiski, P. (2021). Chapter 13 - Public Acceptance of GM Foods: A Global Perspective (1999–2019). I: Singh, P., Singh, A.A., Singh, K.K., Borthakur, A. & Kumar, A. (red.) *Policy Issues in Genetically Modified Crops - A Global Perspective*. Academic Press: 293- 315. <https://doi.org/10.1016/B978-0-12-820780-2.00013-3>
- Skendžić, S., Zovko, M., Živković, I.P., Lešić, V. & Lemić, D. (2021). The Impact of Climate Change on Agricultural Insect Pests. *Insects*. 12 (5), 1-33. <https://doi.org/10.3390/insects12050440>
- Spendrup, S., Eriksson, D., & Fernqvista, F. (2021). Swedish consumers' attitudes and values to genetic modification and conventional plant breeding – The case of fruit and vegetables. *GM Crops & Food*. 12 (1), 342–360. <https://doi.org/10.1080/21645698.2021.1921544>
- Sthal, N.A. & King, J.R. (2020). Expanding Approaches for Research: Understanding and Using Trustworthiness in Qualitative Research. *Journal of developmental education*. 44 (1), 26-28.
- Stein, A.J. (2015). Acceptance of “GM food” in Europe: What People Say and Do. ResearchGate. doi:10.13140/RG.2.1.1052.9127
- The World Bank (2023). What is food security?. <https://www.worldbank.org/en/topic/agriculture/brief/food-security-update/what-is-food-security> [2023-03-29]
- Trivedi, M., Singh, R., Shukla, M. & Tiwari., R.K. (2016). GMO and Food Security. Omkar, I. (red). *Ecofriendly Pest Management for Food Security*. Cambridge: Academic Press. 703-726.
- Twardowski, T., Woźniak-Gientk, E., Tyczewska, A., Perisic, M., Beniermann, A., Eriksson, D., Vangheluwe, N., Gheysen, G., Cetiner, S. & Abiri, N. (2022). Public perception of plant gene technologies worldwide in the light of food security. *GM Crops & Food*. 13 (1), 218-241. <https://doi.org/10.1080/21645698.2022.2111946>
- Vigani, M. (2017). The Role of Mass Media and Lobbies in the Formulation of GMO Regulations. I: Adenle, A.A, Morris, E.J. & Murphy, D.J (red.)

- Genetically Modified Organisms in Developing Countries*. Cambridge: Cambridge University Press. 200-212.
- Weale, A. (2010). Ethical arguments relevant to the use of GM crops. *New Biotechnology*. 27 (5), 582- 587. <https://doi.org/10.1016/j.nbt.2010.08.013>
- World Health Organization (2022). *Food, Genetically modified*. https://www.who.int/health-topics/food-genetically-modified#tab=tab_2. [2022-12-10]
- Woźniak, E., Tyczewska, A. & Twardowski, T. (2021). A Shift Towards Biotechnology: Social Opinion in the EU. *Trends in Biotechnology*. 39 (3), 214 – 218. <https://doi.org/10.1016/j.tibtech.2020.08.001>
- Wunderlich, S. & Gatto, K. A. (2015). Consumer perception of genetically modified organisms and sources of information. *Advances in Nutrition*. 6 (6), pp. 842–851. <https://doi.org/10.3945/an.115.008870>
- Zhang, C., Zhang, H. & Wohlhueter, R. (2016). Genetically modified foods: A critical review of their promise and problems. *Food Science and Human Wellness*. 5 (3), 116-123.

Appendix 1

Interview – guide

Briefing

Thank you for your willingness to participate and be interviewed for this study. During this interview, I want to learn about your perception of GMOs. This interview will be recorded, and notes maybe be taken during the interview. The material from this interview will be used in my master’s thesis and you will be anonymous.

Is it okay that the interview is recorded?

Do you have any questions before we start the interview?

Interview Questions:

- What is GMO?
- What is your knowledge of GMOs?
- What is your opinion on GMOs?
- What do you think are the main advantages of GMOs?
- What do you think are the main disadvantages of GMOs?
- Where have you gained your knowledge about GMOs from?
- Where do you prefer to get your information on GMO development from?
- What type of information about GMOs, is for you, the most important to receive?
- Would you consume GMO food?
 - o If yes, why?
 - o If not, why?
- What is your opinion on the use of GMOs in the food production system?
- What role do you think GMOs will have in the future of food production?
- What is your opinion on the use of GMOs in agriculture?

Debriefing

Are there any aspects that you consider important to discuss that we have not discussed during this interview?

Thank you for participating in this interview.

Publishing and archiving

Approved students' theses at SLU are published electronically. As a student, you have the copyright to your own work and need to approve the electronic publishing. If you check the box for **YES**, the full text (pdf file) and metadata will be visible and searchable online. If you check the box for **NO**, only the metadata and the abstract will be visible and searchable online. Nevertheless, when the document is uploaded it will still be archived as a digital file. If you are more than one author, the checked box will be applied to all authors. You will find a link to SLU's publishing agreement here:

- <https://libanswers.slu.se/en/faq/228318>.

YES, I/we hereby give permission to publish the present thesis in accordance with the SLU agreement regarding the transfer of the right to publish a work.

NO, I/we do not give permission to publish the present work. The work will still be archived and its metadata and abstract will be visible and searchable.