Scrape off or throw away?
– Consumer attitudes to mouldy foods at home

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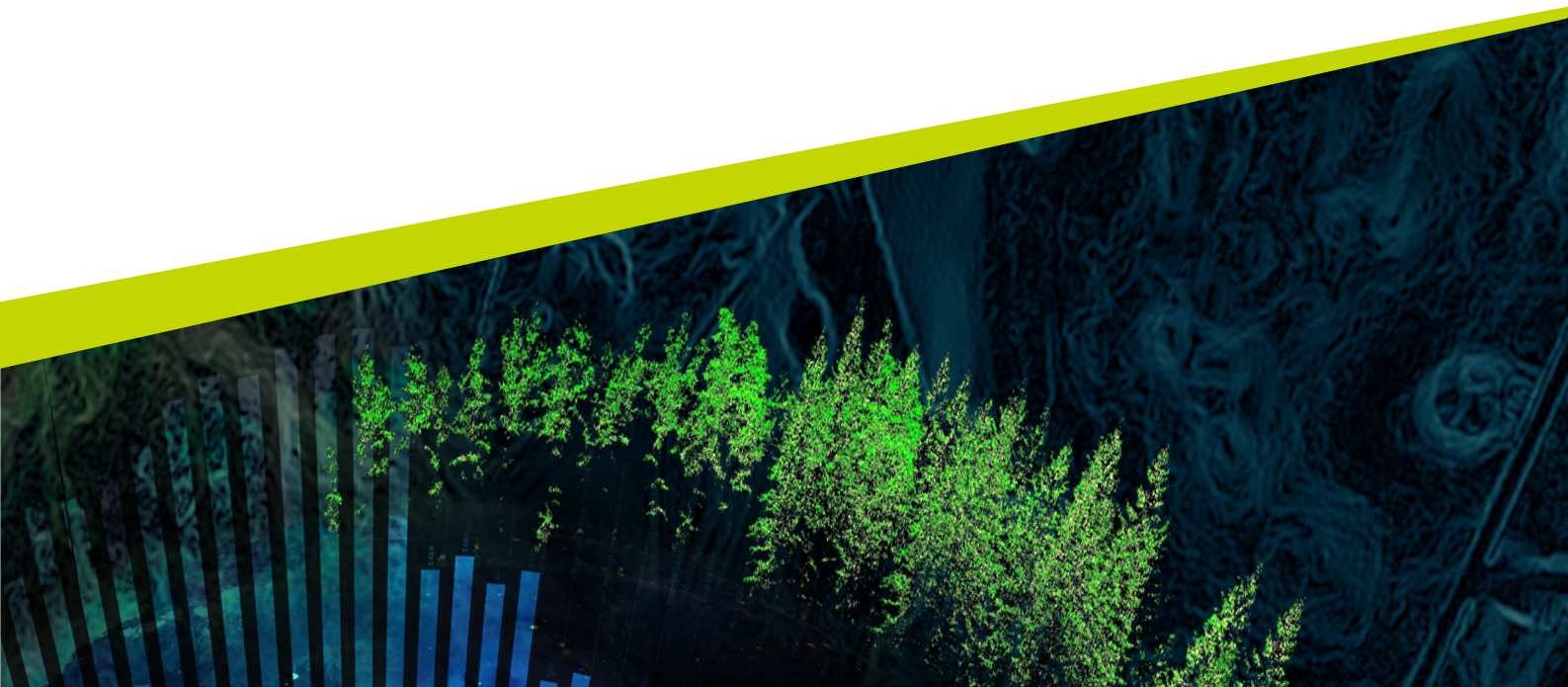

Scrape off or throw away? – Consumer attitudes to mouldy foods at home

Hur hanterar svenskar mögliga livsmedel – kassera produkten eller avlägsna möglet?

Lotta Jonasson

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Abstract

Knowledge about how consumers handle mouldy food products at home is limited. It is of interest to investigate these aspects more closely, since some moulds can produce mycotoxins and other secondary metabolites that could be harmful to human health. A mainly picture-based survey regarding how participants would handle a variety of mouldy foods was distributed through social media and email, with a target of collating answers from both genders and a range of age groups. The participants were presented with a photo of mouldy foods with numbers indicating where they would remove part of the product, alternatively if they would discard the whole mouldy product.

The survey generated 650 full answer-sets from people resident in Sweden. Participants were not evenly distributed by gender (84% women, 14% men), and this was treated in the statistical analysis of the results. About 39% of the participants agreed that if the mouldy part of the product was discarded, the rest of the product would be safe to eat. About 79% of the precipitants disagreed with the statement "mouldy food is not dangerous, and the mouldy food could be consumed". When looking at the responses to the picture-based questions, products that the majority of participants would discard substantially or completely if mouldy were salsa, béarnaise sauce, liver pâté, crème fraiche, Turkish yoghurt and squash (cordial). Products which showed a greater range of opinions about how participants would handle them when mouldy were bread, peach, pear, carrot, cheese and apple sauce.

Mouldy food samples (n=31) from Swedish household were collected and the moulds present were identified according to two methods: traditional PCR-sequencing combined with morphology, and MALDI-TOF, to get a snapshot over which species were present in the food products. The 38 mould isolates and identified showed that the majority of the species were not known producers of the regulated mycotoxins. The exception was the mould that was identified from pear and apple, *Penicillium expansum*, which can produce the regulated mycotoxin, patulin.

Keywords: Mould, Survey, Consumer, Food waste, Mycotoxin, Sweden

Sammanfattning

Kunskapen om hur konsumenter hanterar mögliga livsmedel i hemmet är begränsad. Det är av intresse att studera detta närmare, då vissa mögel kan producera mykotoxiner och andra sekundära metaboliter som kan vara skadliga för människors hälsa. En enkät till stor del bestående av bilder på mögliga livsmedel distribuerades via sociala medier och email, med målet att få svar från båda könen och ett brett åldersspann. Deltagarna fick se ett flertal bilder på mögliga livsmedel med numrering för att indikera hur mycket det skulle avlägsna av produkten, alternativt om det skulle kasta hela produkten.

Enkäten genererade 650 svar från personer boende i Sverige. Det var inte jämnt fördelat mellan könen i enkäten (84% kvinnor och 14% män), och detta behandlades genom statistisk analys av resultatet. Ungefär 39% av deltagarna höll med att om den mögliga delen av produkten borde avlägsnas, och att resterande del av produkten var säker att konsumera. Ungefär 79% av deltagarna höll inte med i uttalandet ”möglig mat är inte farligt, möglig mat kan konsumeras”. När man tittat på deltagarnas svar på bilderna av mögliga livsmedel, så skulle majoriteten av deltagarna ta bort stora delar av produkten eller kasta hela om möglet finns på: tacosås, bearnaisesås, leverpastej, crèmefraiche, turkisk yoghurt eller saft. Andra produkter som visade en bredare fördelning i hur det hanterades var mögligt: bröd, persika, päron, morot, hårdost och äppelmos.

Spontant mögliga livsmedel (n=31) samlades in och möglet identifierades med hjälp av två metoder: traditionell PCR-sekvensering kombinerad med morfologi och MALDI-TOF för att få en ögonblicksbild över vilka arter som fanns på produkterna. De 38 mögel som identifierades visade att majoriteten av arterna inte var producenter av det reglerade mykotoxinerna. Undantaget var möglet på päron och äpple, *Penicillium expansum*, som kan producera mykotoxinet patulin.

Nyckelord: Mögel, Enkät, Konsument, Matsvinn, Mykotoxin, Sverige

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Abbreviations

EU	European Union
FSA	Food Standards Agency UK
FSC	Food Supply Chain
FAO	Food and Agriculture Organization
IARC	International Agency for Research on Cancer
SDG	Sustainable development goals
SFA	Swedish Food Agency
UN	United Nations
USDA	United States Department of Agriculture

1. Introduction

All countries set their own recommendations for how mouldy food products should be handled. The Swedish Food Agency (SFA) gives certain recommendations for handling of products like apples and hard cheese (Olsen & Svanström, 2017) based on scientific literature; in contrast, the United States has special recommendations for the handling of certain products but it is less clear from information available on the web what kind of literature the recommendations are based on (USDA, 2013). In the United Kingdom, the food safety authority recommends their citizens to discard all product if they have gone mouldy (FSA, 2020). There can be concerns with moulds since some species can produce secondary metabolites that are known as mycotoxins.

Mycotoxins occur naturally in feed and food and are produced by a broad range of filamentous fungal species (Milićević *et al.*, 2016). The intake of food and feed that are contaminated can be a threat to animal and human health. Humans can ingest mycotoxins direct by consuming infected food or by "carry-over" of metabolites or mycotoxins from animal products. The crops that often are connected to mycotoxins are small cereal grains, cottonseed, corn, peanuts and tree nuts. The European Union has legislation for all member states to follow regarding maximum levels of mycotoxins, depending on their toxicity and their thermal and chemical resistance. The levels of mycotoxins that are accepted vary between processed and unprocessed products, and the target group for consumption of the product (1881/2006, 2006). There are over 400 secondary metabolites that are recognised as mycotoxins but only a few that are regulated by legislation (Sulyok *et al.*, 2010). Depending on their diets, consumers are exposed to different levels of mycotoxins; also, the amount of consumption of mouldy food stored at home is uncertain (Olsen *et al.*, 2019). Foods of all kind can be contaminated with mould even if the products have decreased pH or low water activity (Coton & Dantigny, 2019).

The world population is increasing, and food production needs to increase or the food losses in the food supply chain must be reduced. Today nearly one third of all food that are produced is lost in the food supply chain (UN, 2015b). The United Nations (UN) has formed sustainable development goals: one is "responsible consumption and production" (SDG 12). The goal aims, for instance to halve the

amount food waste by 2030 at retail and consumer level. One of the most common reason to waste food today at consumer level is because it has gone mouldy. The UN has one other goal (SDG 2) called “zero hunger” that has a target in 2030 for hunger to end and to ensure access for all people to safe, nutritious and enough food all year around (UN, 2015a). Food contaminated with mycotoxins can be considered as non-safe since some of the mycotoxins are well known for impacting health as neurotoxins, carcinogens, etc (Alshannaq & Yu, 2017).

The aim of this project is to gain an overview of how Swedish people handle mouldy food in their households, and a snapshot of what kind of moulds are present on spontaneously mouldy food products in Swedish homes. The main questions for this project deal with the knowledge that Swedish people have about moulds and mycotoxins, and how they handle different food products when mouldy. We aim to map trends to see if people handle products the same way, or if there are differences between gender and age groups. A secondary goal is to identify the kinds of moulds found on a selection of naturally mouldy products, and classify if they are potentially harmful moulds or only spoilage moulds.

2. Background

2.1. Mould in general

Moulds are various species belonging to the fungal kingdom, often recognised when they cover surfaces as thread-like mycelia and often producing masses of asexual or sometimes sexual spores. The asexual spores can be released by airborne dispersal and may survive long-term in the air. The action of moulds can be divided into biodegradation and spoilage (Moss, 2006). The difference is that moulds are responsible for degradation of large amounts of organic material and serve as important agents in the nutrient cycle of the biosphere, called biodegradation. However, when this happens on materials important for humans, for example food or feed for animals, the process is instead called spoilage.

2.1.1. How and why does food mould?

There are five major factors that influence the growth of moulds on food. The factors are pH, available nutrients, water activity, oxygen availability and temperature. The optimal growth environment differs between species of moulds. *Aspergillus* spp., for example, have an optimum around 30 °C and are therefore more common in tropical or subtropical regions, whereas *Penicillium* spp. have an optimum at 20 °C and are more common in temperate parts of the world. When the water activity is lower than 0.6, there is no growth of any microorganism and therefore food spoilage is not due to microorganisms. Instead chemical reactions can occur and cause spoilage such as oxidation, or there can be insect damage. Mould growth is in general inhibited by low temperature but there are some species that can grow at low temperatures and can therefore cause spoilage in refrigerated products. To prevent mould spoilage, it is important with good hygiene during both production and storage of food. Many moulds produce airborne spores and therefore indoor air quality is critical; this is of course difficult to control at home. Control of both production lines and storage facilities to get early information about build-up of mould spores is important. In household the factors mentioned before are very important to maintain, namely, to store the products under the right

conditions and have good hygiene to avoid contamination when using the same utensil for different products etc.

Fruit and vegetables represent a certain raw food category because they have their own natural antifungal mechanisms. Fungal pathogens can infect fruit directly via penetrating the fruit or by wounds that have occurred pre- or post-harvest (Prusky *et al.*, 2014). The symptoms of disease can occur during harvest, shipment or storage. Fruits have natural chemical and mechanical barriers, such as the peel, that are relatively resistant to spoilage by microbes (Moss, 2006). The barrier changes during ripening, and an unripe fruit has a better resistance against pathogens (Adikaram *et al.*, 2010). In fruits, natural antifungal substance are present that prevent invasion of fungi. The role of antifungal substances differs between types of fruit – in some they play a supportive role to the defence system, whereas in others such as avocado or mango, the antifungal substances have an actual protective role. Due to low pH in many types of fruits, moulds have advantages over bacteria in spoilage of fruit (Moss, 2006). Fresh vegetables can have relatively high numbers of microorganism at harvest due to their contact with soil during growth, but spoilage losses are often not due to plant-pathogens (Tournas, 2005). Microorganisms can in later steps during harvest, transport, production and/or storage contaminate the vegetables. The pathway for fungi to break down plant tissue is similar to that mentioned for fruits. Different moulds can have preferences for certain substrates and therefore are more or less common depending on the type of vegetable.

2.2. Why can mouldy foods be dangerous to consume?

Some moulds can produce secondary metabolites, known as mycotoxins. Production can occur during different steps in the food chain, from before harvest in the field, to storage of products at home. The most well-known and studied mycotoxins for which regulations exist include ochratoxin A, aflatoxin, citrinin, zearalenone, patulin, fumonisins B_1 and B_2, deoxynivalenol, (1881/2006, 2006). Some other well-studied toxins that are not regulated according to EU are alternariol, tenuazonic acid and other *Alternaria* toxins, penitrem A, roquefortine and mycophenolic acid. Mycotoxins are of interest since they are of concern for human and animal health. Some mycotoxins give acute symptoms after consumption of contaminated food while other are linked to long-term effects on health.

The most common mould species that produce mycotoxins in food are quite well known, and the presence of these species on food implies a risk that the food is

contaminated with mycotoxins. In following section, the most common species that produce mycotoxins that are regulated in the EU commission regulation No 1881/2006 will be presented.

Penicillium expansum and other closely related *Penicillium* species produce the mycotoxin patulin during rotting of pears and apples (Pitt, 2014a). Patulin can be found in different kind of food products but is not stable in flour, cheese, wet maize and orange juice., The total tolerated intake per day and per kg bodyweight is 0.4 µg; furthermore, when this value is used to set limits, special regulations are applied when the product is intended for infants and children. Mouldy fruits were studied in Denmark to see the natural occurrence of *P. expansum* and patulin was found in windfall apples and apple pulp (Andersen *et al.*, 2004).

Fusarium graminearum and other closely related species produce secondary metabolites deoxynivalenol and zearalenone that are regulated in the EU. The *Fusarium* species are mainly a concern in the field where *F. graminearum* infects crops, especially maize. The maximum dose tolerable daily intake is 0.2µg per kilo bodyweight for zearalenone. How the mycotoxin acts in the human body is not clearly understood but there are studies on pigs that show how zearalenone can induce rectal and vaginal prolapse and vulvovaginitis in female pigs (Pitt, 2014e). Deoxynivalenol (DON) has a maximum tolerable intake at 1 µg per kilo body weight and the related trichothecene nivalenol (NIV) has a maximum tolerable intake of 0.7 µg/kg (cited in 1881/2006, 2006). Both mycotoxins are produced by the same fungi but NIV is less common but more toxic (Pitt, 2014c). The acute symptoms after ingestion of DON are diarrhoea, vomiting, fever and abdominal pain in humans and in animals, especially pigs, the refusal to eat contaminated feed is most well-known. DON from cereals appears to be the most common mycotoxin in the Swedish diet (Wallin et al., 2015).

Fusarium sporotrichioides produce the most known toxic trichothecene, known as the T-2 toxin and the HT-2 toxin (Pitt, 2014c). The toxins are often present in smaller grains like wheat and barley. The tolerable daily intake for the combination of the two toxins are 0.06 µg/kg bodyweight.

Fusarium verticillioides is mainly responsible for production of the mycotoxins fumonisins that are regulated in EU to a maximum 1000 µg/kg for maize for direct consumption with lower limits for corn products for children and infants (based on TDI of 2 µg/kg bw; 1881/2006, 2006). There are about 28 isolated fumonisins and the most commonly found is B1, which is often found in maize kernels (Alshannaq & Yu, 2017).

Aspergillus flavus and *A. parasiticus* produce a secondary metabolite that is known as the mycotoxin aflatoxin (Pitt, 2014b). There are four different types of aflatoxins that are of interest; B_1, B_2, G_1 and G_2. The dairy industry is concerned about aflatoxin, since when lactating animals eat feed contaminated with aflatoxin B_1 and G_1, a small part is excreted in milk as aflatoxin M_1 and M_2. The mould species that commonly produce aflatoxins are found in subtropical and tropical regions and food stuff that often are connected to aflatoxin are peanuts and maize. The EU has regulated the amount of aflatoxin in cereals, peanuts, spices, tree nuts, dried fruit, milk and infant formulas (1881/2006, 2006). Limits are in the range of 4-10µg/kg for the different foodstuffs that are aimed for direct consumption with lower limits for foods intended for infants and children.

Species of *Aspergillus* and *Penicillium* produce the mycotoxin ochratoxin A (OTA): the most well-known are *Aspergillus carbonarius, Aspergillus westerdijkiae* and *Penicillium verrucosum* (Pitt, 2014d). The exposure of OTA is connected to consumption of wheat and barley and their products mainly bread (Pitt, 2014d). OTA has also been found in smaller amounts in products such as coffee, beer, wine and chocolate. Limits in the EU are in the range 2-10 µg/kg, with lower limits for foods intended for infants and children (1881/2006, 2006).

In following section some mycotoxins that are not regulated in the European Union will be presented.

Species of *Alternaria* produce *Alternaria* toxins that can cause plant disease in a variety of crops (Barkai-Golan, 2008). Toxins have been found in barley, wheat and sorghum but also in fruit and vegetables such as tomatoes, citrus fruits, olives and apples. *Alternaria* can grow in low temperature and the most commonly found species in fruit and vegetables is *Alternaria alternata*, the most important mycotoxin producing species. The toxicity of metabolites from *Alternaria* to humans is not studied much and therefore knowledge is limited. The EFSA did a diet exposure assessment of Alternaria toxins and the suggestion is that more sensitive analysis methods have to be developed to generate more data (Arcella *et al.*, 2016). Relevant food categories (tomato-based products, cereals and fruits) should be analysed further.

Penicillium roqueforti is used in production of blue mould cheese but is also known as a typical spoilage fungus (Pitt & Hocking, 2009). *P. roqueforti* can produce roquefortine C and mycophenolic acid which are known as mycotoxin. The research on their toxicity is limited but as for now they appear to have a low direct toxicity.

IARC (International Agency for Research on Cancer) has classified aflatoxin as carcinogenic to humans and ochratoxin A as possibly carcinogenic to humans (Ostry *et al.*, 2017). For the other mycotoxin there are inadequate data and therefore no classification.

2.3. Mycotoxin migration in foods

Several studies have looked at different food products that have been inoculated with moulds, and how their secondary metabolites migrate throughout the product to different extents depending on product type. A review in the area was made by Coton and Dantigny (2019), in which they compared how the different experiments were performed and the main findings. Products that have been studied within the field are bread, whole wheat bread, apple and blueberry jams, cream fraiche with different fat content, semi-hard and hard cheese, apples, peppers, tomatoes, tomato pure and dry cured ham and sausages. Similar data which have been used as a basis for some of the SFA recommendations are summarised in 2.5.1 (Olsen & Svanström, 2017).

The experiment setup differs between studies and for example, Olsen et al. (2019) performed their study as follows. Crème fraiche was inoculated with fungal spores from *P. expansum, P. nordicum* and *P. verrucosum* and apple jam with spores from *P. verrucosum*. *P. roqueforti* and *P. crustosum* onto the top centre part to examine the distribution of mycotoxin (Olsen *et al.*, 2019). In the apple jam, fumigaclavine, cyclopenol, andrastin A and questiomycin A could be detected in all layers that were measured (0-2, 2-4 and >4 cm) and two other metabolites were detectable from 0-4cm only, festuclavine and mycophenolic acid. Roquefortine C and penitrem A were only detectable in the top layer. Crème fraiche had two metabolites that were detectible in 0-4cm, namely citrinin and patulin (both regulated mycotoxins). Important to mention is that mycophenolic acid, roquefortine C, penitrem A, citrinin and patulin are all well-recognised as mycotoxins. In a review by Coton and Dantigny (2019) they highlight the importance that many factors affect the migrations of mycotoxin and these should be considered when designing the experiment for future research.

2.4. What have studies shown that the general population knows about the risks from moulds and mycotoxins?

Scientists from Belgium did a survey of awareness of mycotoxins in food and feed. In total there were 520 participants over a wide age range and both women and men answered (Sanders *et al.*, 2015). Food that was infected by mould would be discarded by approximately 85% of the participants and feed infected by moulds would be discarded by 79% of the participants. People in the study appeared to have more knowledge of potential negative effects of bacteria than of moulds. Regarding how mycotoxins are produced, a large number, 60%, of the participants knew that mycotoxins are produced by moulds, but at the same time 38% did not know how mycotoxins were produced. For the toxicity of mycotoxin, about 72% of the participants answered that mycotoxins can cause human toxicity but at the same time about 26% were not aware of that. In the questionnaire, the participants had to answer if a certain product could contain mould and the results showed high awareness in products such as fresh fruit and vegetables, bakery and bread products, dairy products and animal feed. For products like beer or wine and coffee or tea, the participants were unaware of the possibility of mould to grow. However, the authors failed to point out that lower awareness in these kinds of products could be due to the fact that the moulds have contaminated the product before reaching the participants' households. Approximately 28% of the participants answered that they agree/totally agree to consume a product if they removed the mouldy part, while about 58% would throw the product away. If a mouldy product was heated or washed, the majority of the participants would still discard the product, and only a minority would consume the product.

2.5. Recommendations from three different food authorities

There is no general recommendation from the European Union on how the member states should advise their inhabitants on the handling of mouldy food at home. Each country has their own food authority that makes recommendations for their citizens. In following section, recommendations from three different countries are presented, namely, Sweden, United Kingdom and United States.

2.5.1. Recommendation in Sweden

The Swedish Food Authority have information on how to handle food to avoid moulds, and recommendations on how to handle food that have mould, see Table

1. In general, the recommendation is to discard products that have mould (Rosengren, 2017).

Table 1. Recommendation from Swedish Food Authority

Type of product	General information	Recommendation if mouldy
Bread	Mould toxin can travel through the bread because the mould have thin threads – hyphae threads that can easily grow in the bread.	Discard
Berries	Store the product in fridge for short-term storage and in freezer for long-term storage.	Discard
Fruit	Handle the fruit gently to avoid damage on the peel, mould can attach to damaged wounds	Discard
Squash	Use only fresh berries and clean equipment when making squash. Sugar and preservative extend the shelf-life and storing the squash in freezer prolongs the shelf-life.	Discard, When squash has mould, toxin can be in the whole bottle.
Jam and apple sauce	Use fresh fruit and berries in making jam and apple sauce. When less sugar then 500g sugar/kg berries or fruit, the jam should be frozen.	Discard, Exception if the product contains > 500g sugar/kg berries or fruit (33g sugar/100g product). See Table 2.

The SFA has some recommendation for products which are exempt from the general advice to discard if there is mould in the food. These recommendations are presented in Table 2.

Table 2. Special recommendations from SFA

Type of product	Recommendation
Apple	If the mould is less than 2 centimetres is it okay to cut off the mould and 2 cm additional margin
Jam and pomace	Jam and pomace with more than 500g sugar/kg berries or fruit is okay to eat if the mould and 2 cm additional margin are discarded

Hard cheese	Cut off the mouldy spots and at least 2 cm around the mouldy part
Nuts	Sort out discoloured, shrivelled and visible mouldy nuts because they could contain toxin. Brazil nuts should always be cut in half before consuming since they can have moulds in the middle

2.5.2. Recommendations in United Kingdom and United states

According to the Food Standards Agency in the United Kingdom, they recommend to not consume food that is obviously mouldy or rotten (FSA, 2020). That is due to the potential risk from moulds, and especially risk groups should be careful. They state that in some products it is possible to remove the mouldy part, but there is no guarantee that all the mould will be removed so therefore they recommend discarding the entire product.

The United State department of agriculture (USDA) have special advice on how to handle mouldy food (USDA, 2013). As a consumer, you are not supposed to sniff a mouldy item; a food item covered with mould should be discarded by putting it into paper bag or wrapping plastic around it then cleaning the place where the mouldy product was found and checking if surrounding food has been contaminated. Such advice is related to good hygiene, as discussed in section 2.1. 1. In addition, some items have specific information and recommendations on handling if they are spoiled with mould, see Table 3.

Table 3. Recommendation from USDA on how mouldy food should be handled in United States

Type of product	General information	Recommendation
Luncheon meats, bacon or hot dogs	High moisture content food can be contaminated below the surface and bacteria can also grow along with the mould	Discard
Cooked casseroles	High moisture content food can be contaminated below the surface and bacteria can also grow along with the mould	Discard
Leftovers meat and poultry	High moisture content food can be contaminated below the surface and bacteria can also grow along with the mould	Discard

Dry-cured hams and hard salami	Surface moulds are normal for these kind of shelf-stable products	Use. Scrape off the mould from the surface
Grain and pasta	High moisture content food can be contaminated below the surface and bacteria can also grow along with the mould	Discard
Hard cheese	In general mould cannot penetrate deep into the product.	Use. Take away at least 1 inch around and below the product (be careful not to contaminate the knife) After cutting off use new packaging for the cheese
Cheese made with mould	Can be dangerous with moulds that are not a part of the process	Discard soft mould cheeses such as Camembert and Brie if they contain moulds that are not a part of the product. For hard mould cheese, the same procedure as for hard cheese.
Soft cheese	High moisture content food can be contaminated below the surface and bacteria can also grow along with the mould	Discard
Sour cream and yoghurt	High moisture content food can be contaminated below the surface and bacteria can also grow along with the mould	Discard
Bread and pastry	Porous products can be contaminated under surface.	Discard
Fruit and vegetables, SOFT	Vegetables and fruit with high water content can be contaminated below the surface.	Discard
Fruit and vegetables, FIRM	Vegetables and fruit with low moisture content with small mould spots can be cut off. It is hard for the mould to penetrate dense foods.	Use. Take away at least 1 inch around and below the product (be careful not to contaminate the knife)

Jams and jellies	Risk that the mould can produce mycotoxin. Microbiologist does not recommend scooping off the mouldy part and consuming the rest.	Discard
Peanut butter, nuts and legumes	High risk for mould in food that are processed without preservatives.	Discard

UDSA also provides general information that: some moulds are dangerous since they produce mycotoxins and can cause allergic and respiratory problems; where mould can grow; and how consumer can minimize the growth of mould. Also, the fact that mould can be deeper in products than it is possible to see visually, and the most common foodborne moulds are mentioned.

2.6. Food Waste and food losses

The United Nations Food and Agriculture organization (FAO) did a rough estimation based on a study in 2011 that one third of the total produced food in the world was wasted (FAO, 2011). That means that approximately 1.3 billion tonnes per year was wasted. Food waste can be seen at different steps in the food supply chain, from agricultural production to the final consumption in households (Gustavsson *et al.*, 2011). In high- and middle-income countries, more waste is produced late in the supply chain, that is, people waste edible food in the household. In addition, significant losses in earlier steps occur. In low-income countries, more losses are in the early and middle stages of the supply chain and there is less waste at the consumer level. Europe, North America and Oceania had much higher amounts of waste at the consumer level, whereas Sub-Saharan Africa and South/Southeast Asia had the lowest amount of consumer food waste. In numbers, Europe and North America and Oceania contributed to 95-115kg/year and person food waste, whereas Sub-Saharan Africa and South/Southeast Asia only discarded 6-11kg/year and person. The United Nations formed 17 global sustainable developments goals that all member states agreed on in September 2015. One of these goals is responsible consumption (SDG 12). During 15 years between 2015 and 2030, the total amount of food waste should reduce by 50% in every step from agriculture to consumer (UN, 2015b).

The Swedish Environmental Protection Agency published a report on the amount of food wasted in the supply chain in Sweden (Andersson & Stålhandske, 2018). Approximately 1.3 million ton combined unnecessary- and unavoidable

food waste was produced 2018 in food supply chain (FSC) which is equal to 133kg/capita in Sweden. The amount of food waste has increased from previous years. The amounts included waste from agriculture to consumer, and food and beverages that are poured out via the sewage system. Households produced the most food waste – 70% of the total food waste was produced there – followed by supermarkets and agriculture, contributing 8% and 7% of the total amounts, respectively. Calculations showed that 40kg of 133kg/capita was unnecessary food waste and could be avoided. Therefore, the aim of this study was to examine how Swedish consumers handle mouldy foods in their households from a food safety verses food waste perspective.

3. Method

3.1. Participants and objective

To understand how Swedish people handle mouldy products at home, a survey was developed using the online software tool Netigate (Netigate, 2020). The survey was distributed through social media platforms via open link and mail. The survey was online for 28 days from the 15th of June until the 13th of July 2020. The target group for the survey was random with preferences to reflect the Swedish population in general. Of the 684 participants in the survey, 650 were living in Sweden and the distribution between sexes was 84.9% woman and 14.6% man. Both old and young people contributed in the survey and furthermore people with different occupations.

3.1.1. Survey

The survey was designed in an online software tool Netigate (Stockholm, Sweden), see appendix 2 for the survey. The survey was designed as a mixture of scrolling and paging question. The questions were built up with single and multiple answer questions. There was no question which required a free text response. Most of the survey had obligatory questions that had to be answered to be able to continue. The pictures in the survey were prepared such that the respondent would get the impression that the mouldy products were present in a home environment. During the development of the survey, it was tested on persons to confirm that the survey was easy to follow and understand.

The first four questions were designed to clarify who the participants were in terms of age, gender, occupation and if their main residence was in Sweden. Then there were three questions regarding food waste and which type of products that often were wasted and why. Furthermore, there were one question with statements regarding food and mould to understand the participants' knowledge about mycotoxins; then the twelve following questions were pictures of mouldy products and the participants had to take stance on how they would handle them. The last two questions investigated if the participants searched for information regarding

how to handle mouldy foods and if it was easy to find relevant information about this topic.

Preparation of mouldy food products
Most of the food sample used for the survey was bought in a local food store. The following products were inoculated with mould: bread, pâté, crème fraiche, yoghurt, apple sauce, salsa, béarnaise and squash (cordial). The mould used for inoculation was collected from a mouldy bread sample and incubated for 5 days at 25 °C. The remainder of the products used for the survey were spontaneously mouldy products.

Statistics
For the statistical evaluation of the results from the survey Microsoft Excel professional plus 2016 and IBM SPSS statistic 26 program were used. Questions on "quality of the respondents, "consumer attitudes and knowledge" and "image-based question" were statistically evaluated in answer frequency, Person chi-square test and T-test. For the Person chi-square test and T-test the answers from the survey were tested against gender and age.

3.2. PCR and MALDI-TOF

Samples
Thirty-one different spontaneously mouldy food stuff were provided from different households and sampled for mould identification. The growth of mould on the different foodstuff ranged from only one spot of mould to products fully covered in moulds with different coloured mouldy spots.

Sample preparation
The mould from the foodstuffs was spread on MEAC plates for purification at 25 °C for 7 days. In total, 38 moulds were isolated for individual identification.

Mould identification
Moulds were identified using a combination of MALDI-TOF and PCR-sequencing. For the MALDI-TOF, moulds were inoculated on Sabouraud Dextrose Agar plates (Difco™, Becton, Dickinson and Company, USA) between two filters (Cyclopore track etched membrane, Whatman Inc, USA) and grown for 48 hours at 25 °C. Mould mycelium was scraped from the filters and extracted according to the Standard Operating Procedure for Cultivation and Sample preparation for Filamentous Fungi (Bruker Biotyper, Bruker Daltonik GmbH Revision 4, June 2015) and run in the MALDI Biotyper (Bruker Daltonik GmbH, Germany). Spectra

were compared with an in-house database of reference mould strains, and also with the MBT Filamentous Fungi Library 3.0 (Bruker Daltonik GmbH, Germany).

For final confirmation of identity, fungi were also identified by a combination of PCR/sequencing and morphological characteristics, as described in Leong et al., 2012.

4. Results

4.1. Survey data quality and respondents

In total, the survey generated 684 respondents out of 961. Considering that a valid response rate is 60% (Fincham, 2008) or more, the achieved response rate in this survey of 71.2% can be considered acceptable. Of the 961 that started the link, 229 clicked on the link without any further attempt and 48 participants started but did not finish the survey. In the literature, those kinds of drop-offs are separated into two categories; missing values (survey not started) and partial missing values (survey started but not finished) (Lilli *et al.*, 1997). Mainly the drop offs happened at question 9 with the five statements about mould, the image of mouldy bread at question 10 and question 17 with the salsa (see appendix 2 for survey). Question number 9 had a matrix of statements and could have been experienced as more difficult to solve then the other questions, since about 50% of the drop-off happened at question 9.

Of the respondents that finished the survey, 650 persons were living in Sweden. For the results, data from the 650 Swedish residents are used, since the focus is on how Swedish people handle mouldy foods at home. In figure 1, the participants and the Swedish population are presented as percentages of their age categories. Compared with the Swedish population, there is overrepresentation in age group 25-35 years of the survey participants and underrepresentation in two age groups, under 18 only 1 participant and over 65 with 56 participants. The survey was distributed mainly through social media (Facebook and Instagram), but it was planned to also ask people to participate in person via social contacts. Due to Covid -19 restrictions, the Swedish government requested people to implement social distancing and those older than 70 to stay at home, so that part of the survey was cancelled.

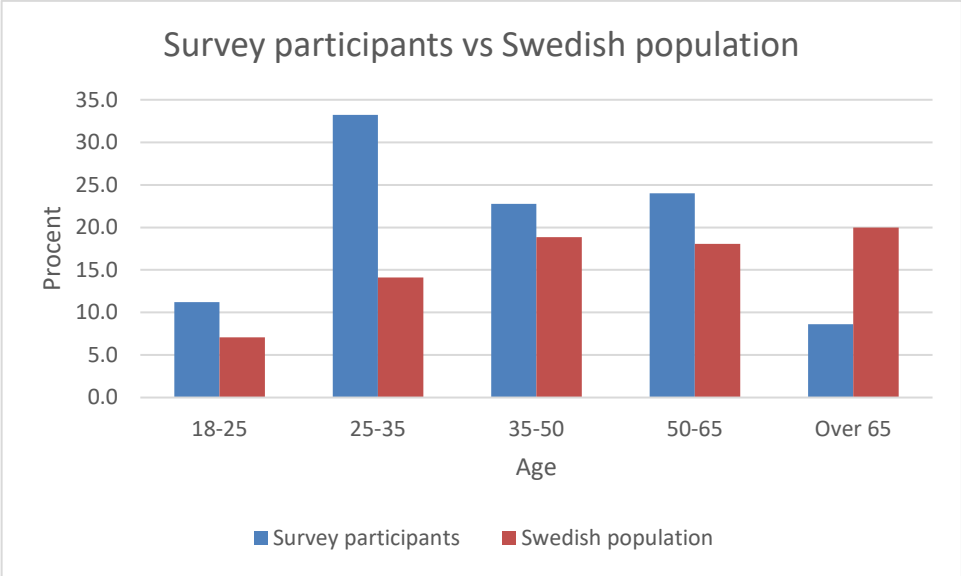


Figure 1. Participants in survey compared to the Swedish population

In Figure 2, the gender and age of the participants is presented. Overall, there are more women than men that participated in the survey and therefore gender is considered in next section, analysing the questions individually and statistically testing if there are differences in response between the genders.

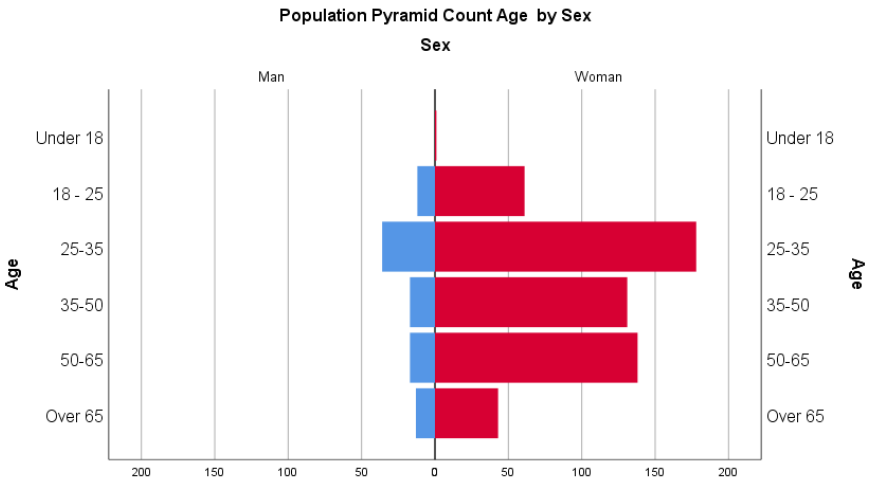


Figure 2 Age and gender of the participants in the survey.

4.2. Presentation of survey results

The main results from the survey are presented and discussed with regard to scientific literature and recommendations from the SFA. Some of the questions are discussed depending on the sex of the participants since there was an overrepresentation of women that answered the survey. Differences between age groups and handling of product is discussed separately.

4.2.1. Consumer attitudes and knowledge

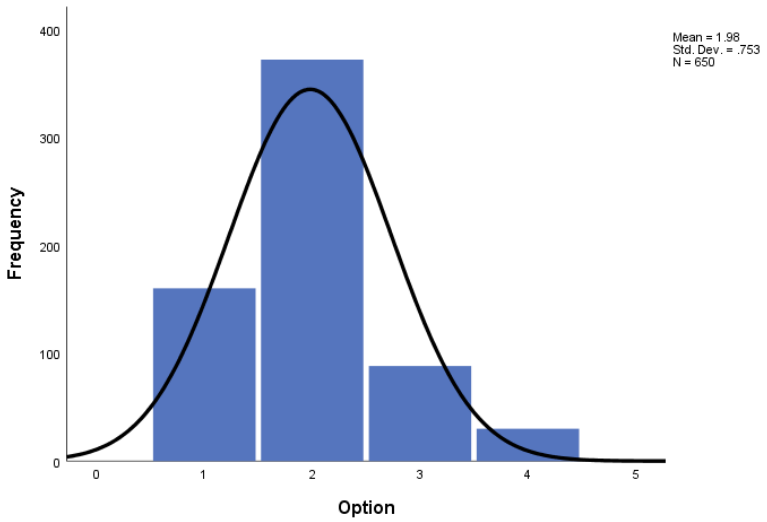


Figure 3. Frequency of responses to "How often do you shop groceries?" where 1 is 1 time/week, 2 is 2-3 times/week, 3 is more than 3 times/week and 4 is less than once/week. The normal distribution curve for responses is shown as a black line.

Most of the participants shop for groceries 2-3 times/week, which can be seen in Figure 3. There are differences in shopping habits between the participants and that can be seen when looking at the normal distribution curve. Less than 5% of the participants shop for groceries less than once a week.

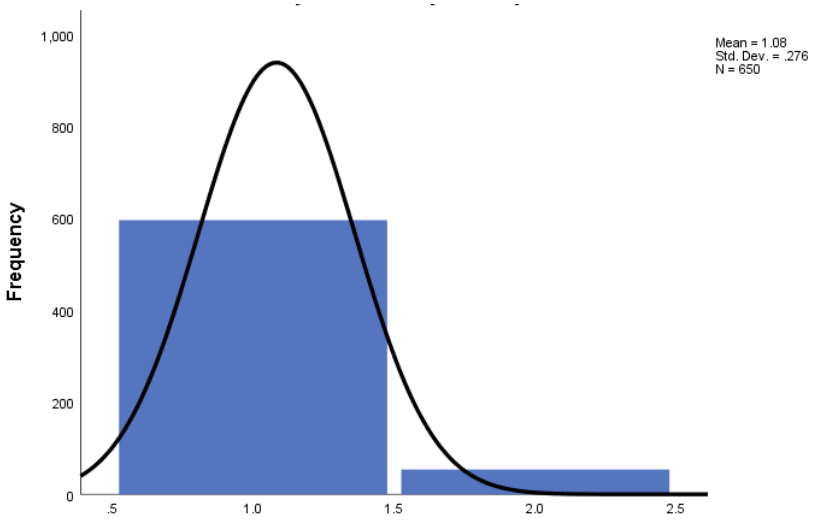


Figure 4. Frequency of responses to "Do you waste food in your household?" where 1 is yes and 2 is no. The normal distribution curve for responses is shown as a black line.

The food waste is presented in Figure 4 where the participants had to answer if they throw away food in their household. The normal distribution curve shows that the majority (about 92%) throw food away.

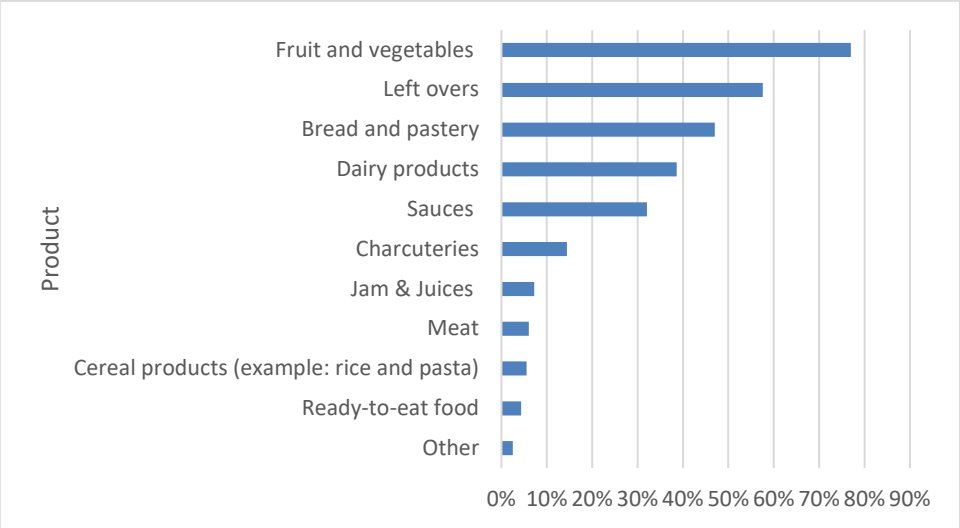


Figure 5. Frequency of responses regarding types of food products discarded in Swedish households.

Figure 5 presents the different food categories where participants could make multiple choices indicating the types of foods that are commonly wasted in their households. The two main categories were fruit and vegetables (80%) and leftovers (58%). Less common was wastage of meat (6%), cereal products (5%) and charcuteries (4%). One food trading company did a survey and asked approximately 1000 Swedish consumers which kinds of food product that they had wasted in the last 30 days in 2019 (Axfood, 2019). Bread was most commonly

wasted followed by different kinds of vegetables and dairy products. Similar trends were observed in our results.

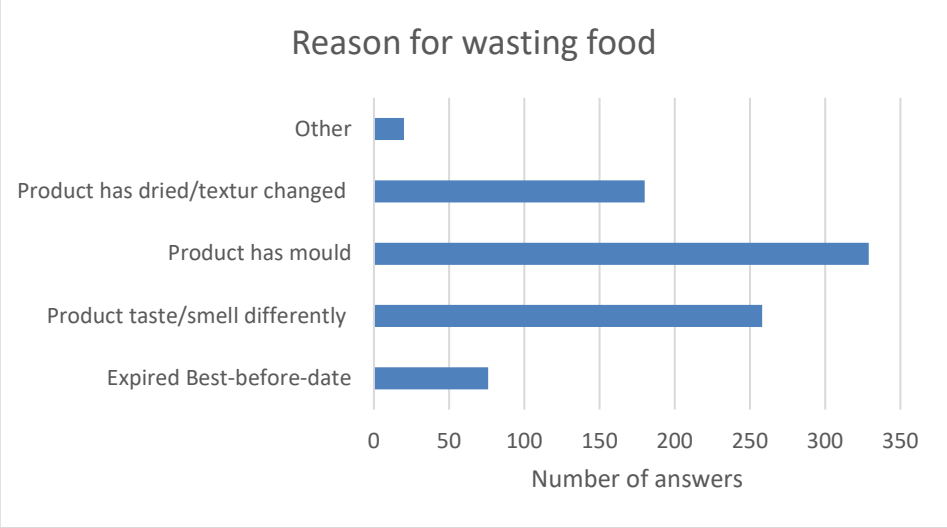


Figure 6. Responses regarding reasons for wasting food (multiple response possible)

Our participants responded that products were often wasted because they had gone mouldy, changed in texture or showed a different smell/taste, see Figure 6. About 20% discarded products because the best-before-date had passed.

The following section of the survey was statistically evaluated regarding answer frequency, using the Person chi-square test and T-test, for statistics see appendix 3. The figures on frequency are presented with a normal distribution curve to visualize if the answers are similar (column fits under the curve) or if the answers from the participants were not normally distributed, i.e. were very different with no clear trend. For the Person chi-square test and T-test, the answers from the survey were tested against gender and age.

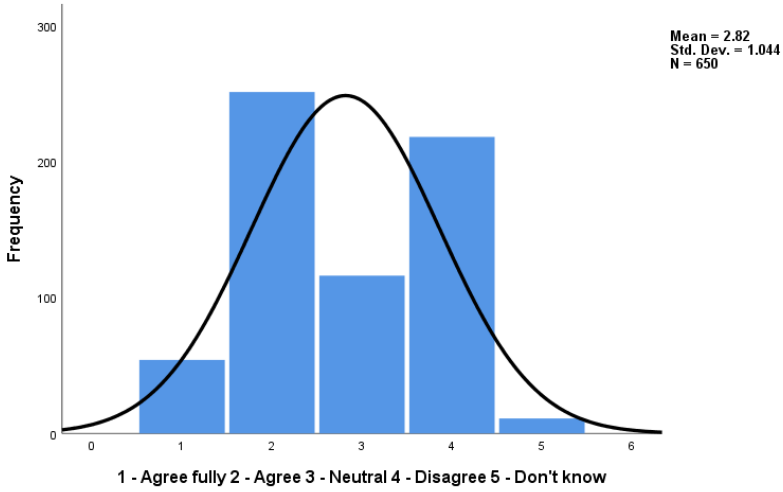


Figure 7. Frequency of responses to the statement "If I take away the mouldy part of the product, I can still eat the rest". The normal distribution curve for responses is shown as a black line.

In Figure 7, the participants were asked if the mouldy part of a product was removed, could the rest of the product still be eaten? About 39% of the participants agreed to the statement and 34% disagreed. The normal distribution curve also shows that the participants choose differently between the options. There were significant differences according to the T-test between men and women, men tending to agree more to the statement and women tending to disagree.

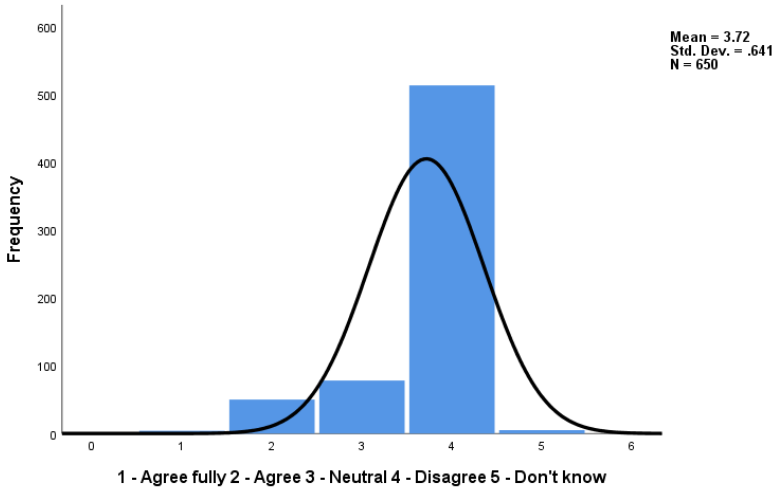


Figure 8. Frequency of responses to the statement "Mould is not dangerous so I can eat the product". The normal distribution curve for responses is shown as a black line.

Of the participants, 79% did not agree with the statement that mouldy food is not dangerous and that the product can be eaten, compared to about 8% that agreed (Figure 8). The normal distribution curve also showed that the majority of

participants disagreed (option 4). There were no significant differences between the genders according to the T-test.

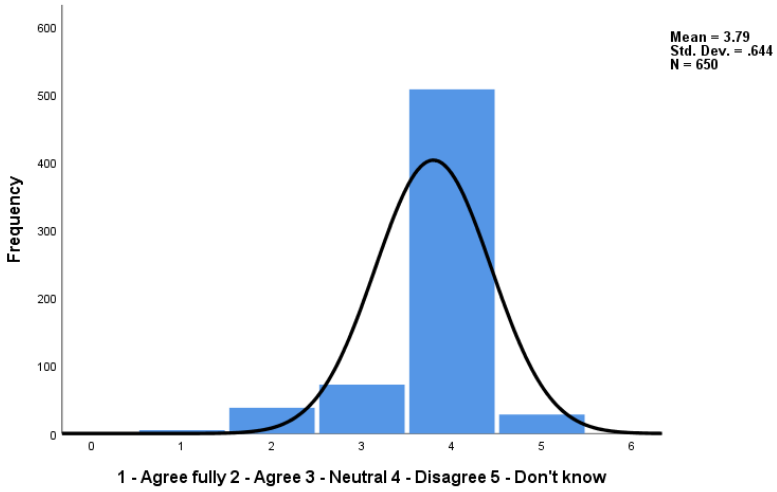


Figure 9. Frequency of responses to the statement "If I wash the mouldy product, it can still be eaten". The normal distribution curve for responses is shown as a black line.

When asked if a mouldy product was washed it could still be eaten, 78% of participants disagreed and 6% agreed (Figure 9). The normal distribution curve also shows that the majority gave the same response. The T-test showed no significant differences between genders.

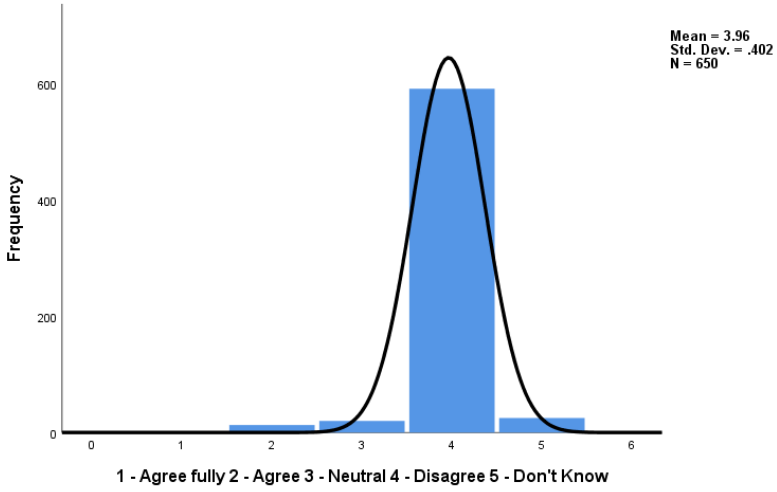


Figure 10. Frequency of responses to the statement "If I heat the mouldy product, I can eat it". The normal distribution curve for responses is shown as a black line.

A mouldy product could not be consumed if it was heated according to 91% of the participants and only 2% said it could (Figure 10). The normal distribution curve also indicated that the participants were unanimous. The T-test show no significant differences between the genders.

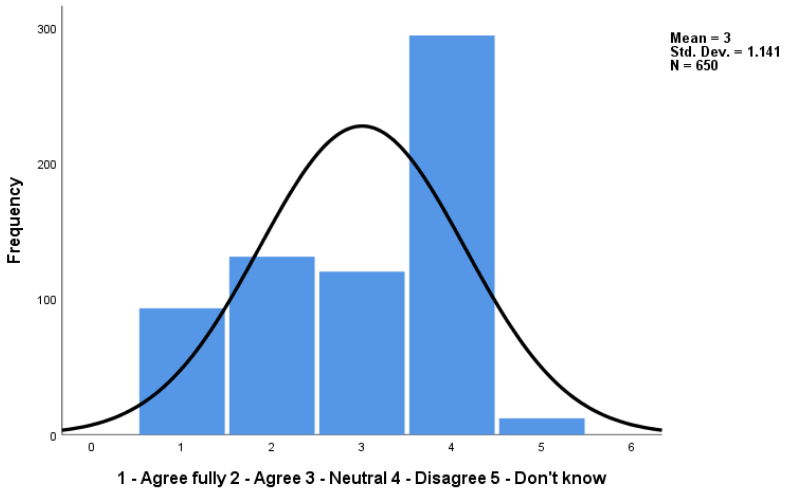


Figure 11. Frequency of responses to the statement "If the product is mouldy, I have to discard the whole product". The normal distribution curve for responses is shown as a black line.

In response to the statement regarding if mouldy food must be discarded, the normal distribution curve showed that the participants answered very differently (Figure 11). About 34% agreed/agreed fully that the whole product has to be discarded and about 38% disagreed. There was no significant differences between genders.

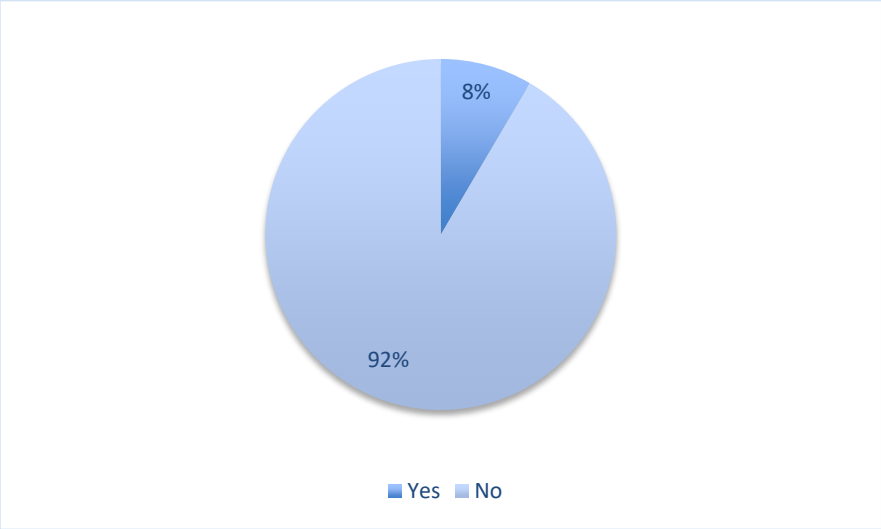


Figure 12. Response to question "Do you search for information if you have mouldy food products at home?"

The participants were asked if they search for information if they had food products that had mould, about 92% did not search for information and 8% did. Of the participants that searched for information 12% thought it was easy to find information respectively 8% that found it hard to find information and 80% did not know.

Overall, for the five "statement style" questions, some showed a clear trend for the majority of the participants whereas for other questions, the participants were not unanimous but instead showed large differences in responses. In four of five statements, gender was not a significant factor affecting responses. It seems like most of the participants agreed that washing or heating a mouldy product does not make it safe to eat. Whereas for the statements about cutting off the mouldy part or completely discarding a product that has mould, the participants answered quite differently from each other. Of the participants, 79% thought that mould is dangerous, so it can be concluded that the majority of the participants are aware of potential negative effects when a mould is present. When comparing the results from the five statement questions for Swedish participants with the knowledge about mould in the Flemish population, there are similarities in the responses for four of the five statements (Sanders *et al.*, 2015). In both surveys, the participants answered over quite a wide range on the statement about "If the mouldy part is removed the rest of the product can be consumed": about 34% the Swedish participants disagreed compared to about 58% disagreed/disagreed fully for the Flemish participants. That shows some differences between the Swedish and the Flemish participants and there might be some differences in how mouldy foods are handled in households in the different countries. For the rest of the four statements, there were more similarities between the surveys. Of the Flemish participants, 89% did not think heating make the product safe to eat compared to 91% of the Swedish participants. Likewise, 84% of Flemish *vs* 78% of the Swedish participants did not agree that it is safe to eat a mouldy product if it has been washed. In both surveys, participants answered differently from each other on the statement "if a product has mould, the whole product has to be discarded.

The majority of the participants seem to not search for information regarding how to handle food. It would have been of interest to ask how they base their decision on how to handle mouldy products instead.

4.2.2. Image-based questions

Bread

A.

B.

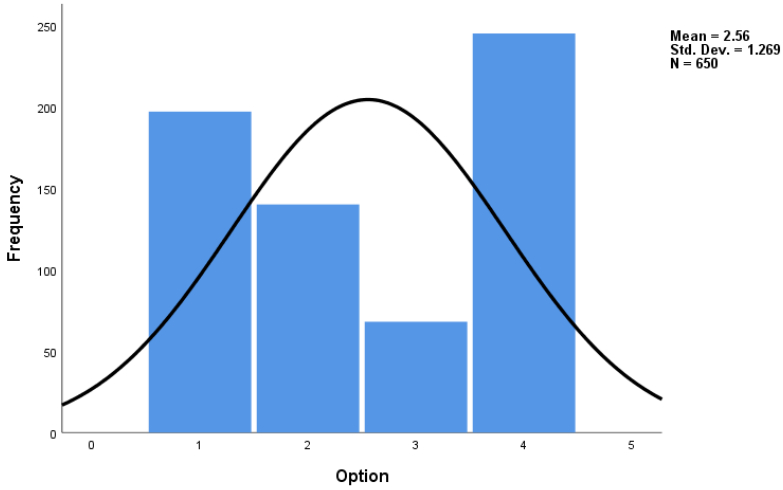


Figure 13. Mouldy bread with number-markings for participants to indicate where they would discard the bread, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

When presented with Figure 13A, participants were requested to indicate at which marking they would choose to discard the bread, according to their own opinion. Of the 650 participants, 30% would take away only the bread slice with mould (shown at mark 1 in Figure 13A) followed by 21% that would take away additional slices, to mark 2. About 38% of the participants would discard the product completely (Figure 13B). These responses did not follow the normal distribution

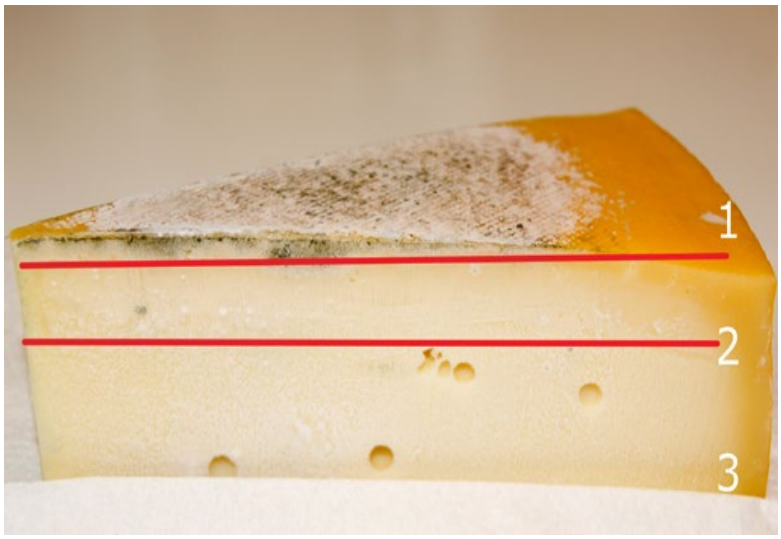
curve around the mean, so there were clear differences in how the participants would handle the bread, which is also shown in the standard deviation.

In the statistic evaluation, the Chi-square showed a variance between women and men's answer to 1.7% so for the T-test they are assumed to have equal variance and this showed a significant difference at 0.6%. That means that there is a significant difference between the genders in how they handle mouldy bread in this survey. When comparing the mean value of the groups, men tended to discard at marking two (mouldy slice plus one extra slice) while women tended to discard at marking three (mouldy slice plus three extra slices).

The recommendation from the SFA is that bread should be discarded if there is mould on it (Rosengren, 2017); likewise, the USDA recommends completely discarding mouldy bread and pastry due to their porosity (see Section 2.5.2). According to the data from the survey, 62% of the participants would not completely discard the bread, instead they choose to discard the bread partially between marking 1 and 3. The recommendation from the SFA is mainly based on a study from 1979 examining spontaneously mould white bread after 2 weeks in room temperature. The result in that study showed that aflatoxin was present in and close to the mould spot at between 0.04 to 15 mg/kg. In1980, a study examining 50 mouldy bread samples found out only one bread sample contained the mycotoxin OTA at level 0.21mg/kg; no other mycotoxins were detected (Osborne, 1980). The SFA state that their recommendation regarding handling of bread is based on precautionary principle (Olsen & Svanström, 2017).

Hard cheese

A.



B.

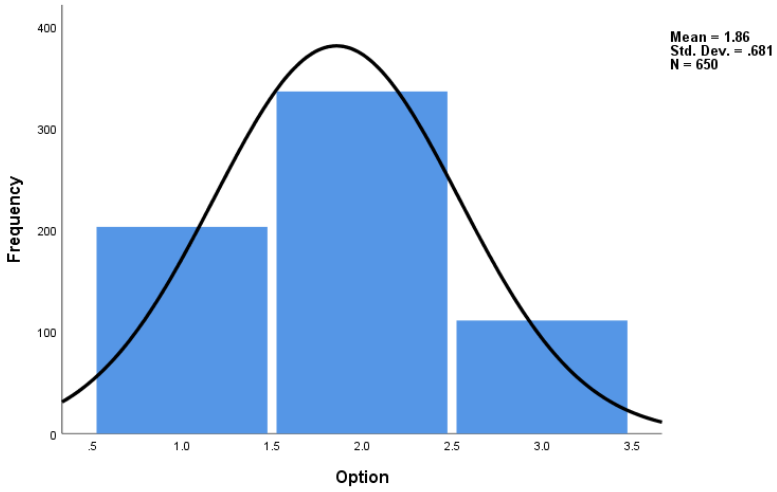


Figure 14. Mouldy hard cheese with number-markings for participants to indicate where would discard the cheese, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

Approximately 31% of the participants would discard the mouldy cheese at mark 1, 52% at mark 2 and 17% would discard the whole cheese (Figure 14B). The normal distribution curve visualizes that participants handle the cheese differently, because there is a large spread of values under the normal curve instead of the vast majority of responses centring around the mean.

The Pearson Chi-Square test showed significant differences in variance between the genders, so for the T-test non equal variance was assumed. The T-test showed no significant gender differences in handling of the hard cheese. The mean value at

1.86 was the same for both men and women and it seems to be most likely to discard at mark 2 (approximately 2 cm from the mould). The recommendation for hard cheese from the SFA is to discard 2 cm around the mould spot (Rosengren, 2017). In the survey, approximately 50% of the participants would cut at mark 2 which is about 2 cm from the mould. Regarding earlier studies on mouldy cheese, a review about the presence of filamentous fungi and mycotoxins in cheese ((Hymery *et al.*, 2014) mentions that the main findings regarding mycotoxin in cheese are from contamination before or during production of cheese.

For future surveys, it would be of interest to also ask the participant how they would perform the removing of the mould. To see if there is risk for contamination of other part of the cheese when removing the mould. In Swedish household the cheese plane is often used and it would be interesting to see if it is also used to remove mouldy part. As the USDA recommendation states in section 2.5.2, it is important to not contaminate the knife when removing mould from hard cheese (Table 3). If the cheese plane is used for removing it would be a risk for contamination of non-mouldy part of the cheese.

Liverpâte

A.

B.

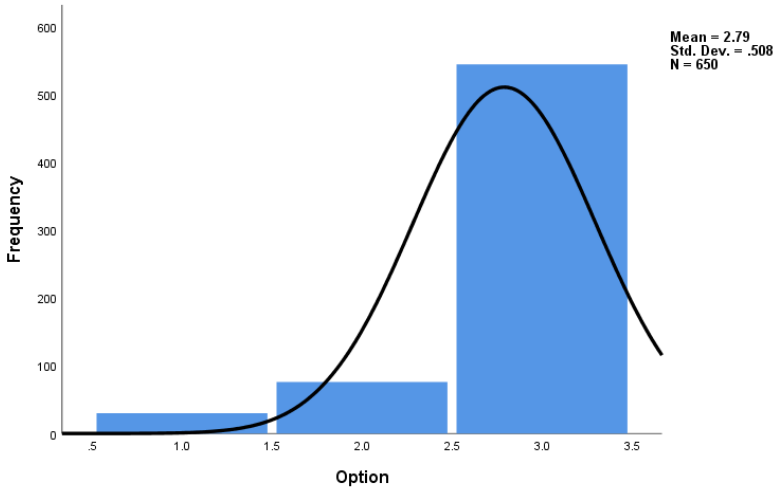


Figure 15. Mouldy liver pâté with number-markings for participants to indicate where would discard the pâté, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

Approximately 84% of the participants would discard the liver pâté completely compared to 12% that would take away to mark 2 and 4% that scrape off the mould (Figure 15). The normal distribution curve also shows that the majority of the participants would discard the pâté.

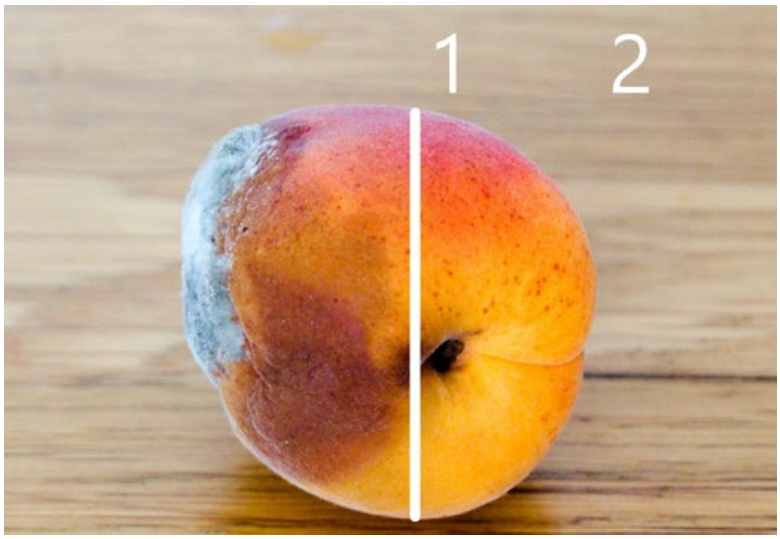
The T-test showed that there were significant differences between genders in how they handled the pâté. Men tended to cut off less, with 8.4% of the men selecting mark 1 compared to 4.6% of the woman. That is also showed in the mean value for the genders, with mean value for women and men 2.8 and 2.6, respectively, which

indicates that more of the men tend to choose removing less of the pâté. The SFA has the general recommendation that mouldy products (which would include liver pâté) should be discarded and the majority of the participants do so. There are no known studies on how mycotoxins migrate in pâté, so to change the recommendation, specific research would be needed.

Fruit and vegetables

The result from the image of fruit and vegetables will be presented first then in the end of the section main findings will be discussed and referred to the literature.

A.



B.

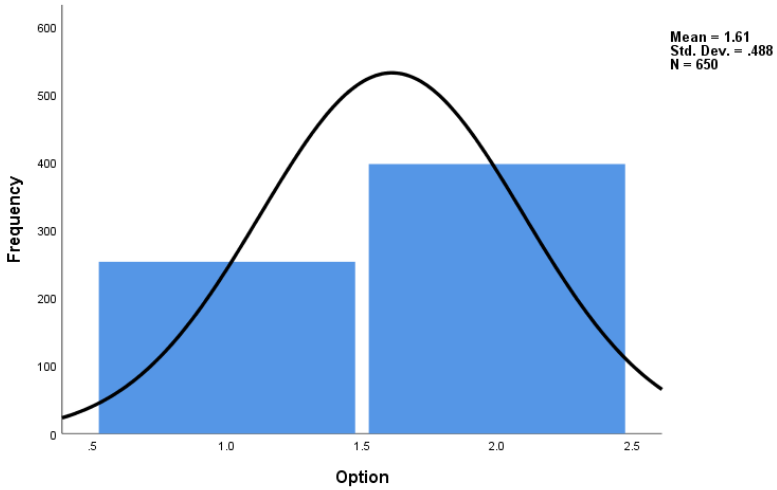
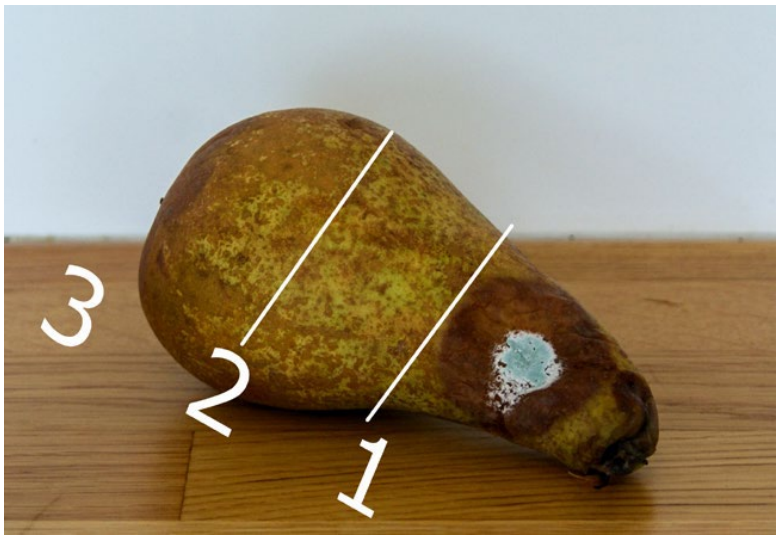


Figure 16. Mouldy peach with number-markings for participants to indicate where would discard the peach, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

Comparing the responses with the normal distribution curve showed that the participants were divided between handling the peach in different ways (Figure 16B). Approximately 39% of the respondents would discard to mark 1 and the rest would throw the peach away. There were no significant differences between gender responses, according to the T-test.

A.



B.

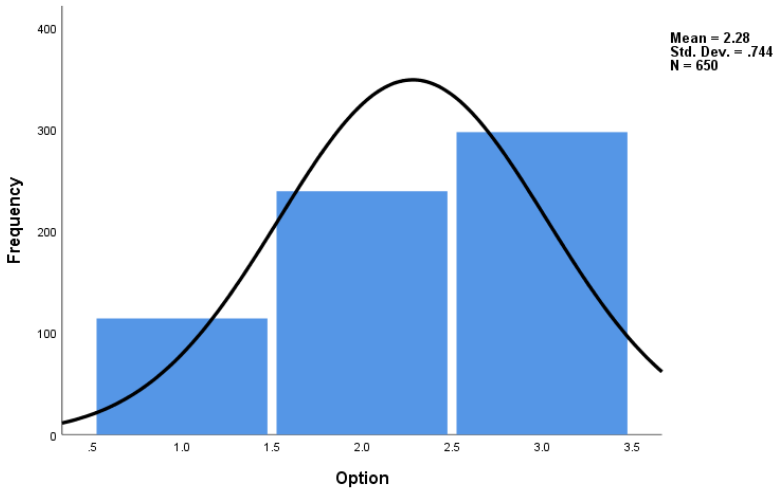
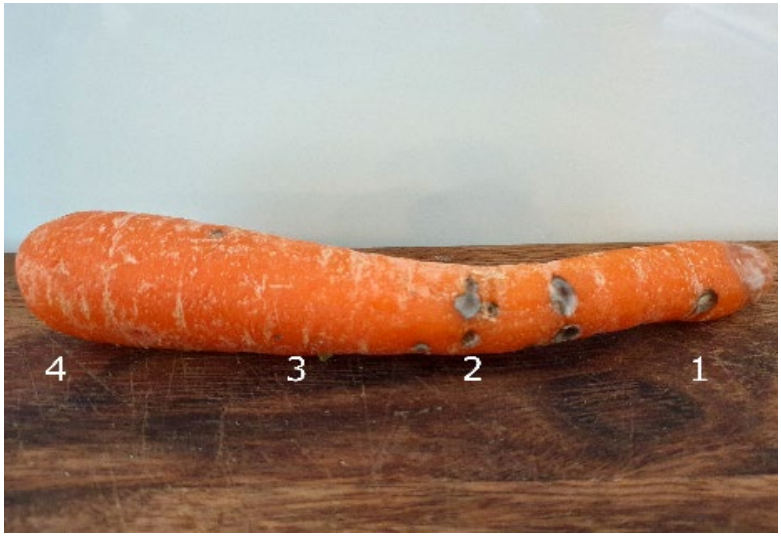


Figure 17. Mouldy pear with number-markings for participants to indicate where would discard the pear, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line

Comparing the responses with the normal distribution curve showed that the participants would handle the pear differently (Figure 17). Approximately 18% would cut off to mark 1, 36% to mark 2 and 46% would discard the whole pear. The T-test showed no significant differences between the genders.

A.



B.

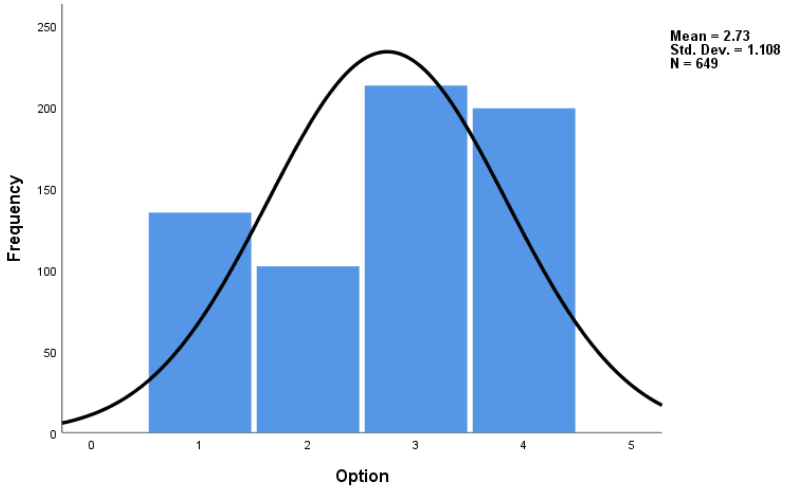


Figure 18. Mouldy carrot with number-markings for participants to indicate where would discard the carrot, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

Comparing the responses with the distribution of the normal curve showed that participants would handle the mouldy carrot differently (Figure 18). About 21% would remove the peel, 25% to mark 2 and most (33%) answered that they would take away to mark 3, and the rest would discard the carrot. The chi-squre test showed that not equal variance could be assumed and the T-test showed no significant differences between genders.

For fruit and vegetables, there seemed to be quite a large variation in how participants would handle the products. The recommendation from the SFA is to discard the products, but that did not seem to be what all participants do. For both peach and pear, 39% and 54% of the participants, respectively, would only partially discard the products. Since both of the products have a high water content, it can be a potential risk for mycotoxin migration into the whole product,

depending on what species of mould that are present. A study by Dong-mei et al (Dong-mei *et al.*, 2017) looked at how patulin migrated in pear tissue. They found that depending on lesion size, different amount of "healthy" tissue should be removed to minimize the risk for patulin. In the survey, 18% would cut off beside the end of the lesion and that is not enough – when the lesion is about 10mm, at least 30mm of the surrounding tissue should be discarded. When looking at the carrot, 79% of the participants would partially discard the product. The SFA recommends discarding the product, and when looking at the carrot in Figure 17A, there are quite deep penetrating mouldy spots. Nevertheless, about 21% of the participants would only remove the peel and this could be a risk for consuming toxic substances. However, there do not appear to be any particular mycotoxin risks associated with carrots reported in the literature today. Compared to the UDSA recommendation regarding hard vegetables (Table 3) where they recommend cutting off 1 inch around the mould. There are uncertainties since they do not state what kind of literature they base the recommendation on.

Semi liquid and liquid food products

The result from the image of semi liquid and liquid products will be presented first then in the end of the section main findings will be discussed and referred to the literature

A.

B.

.

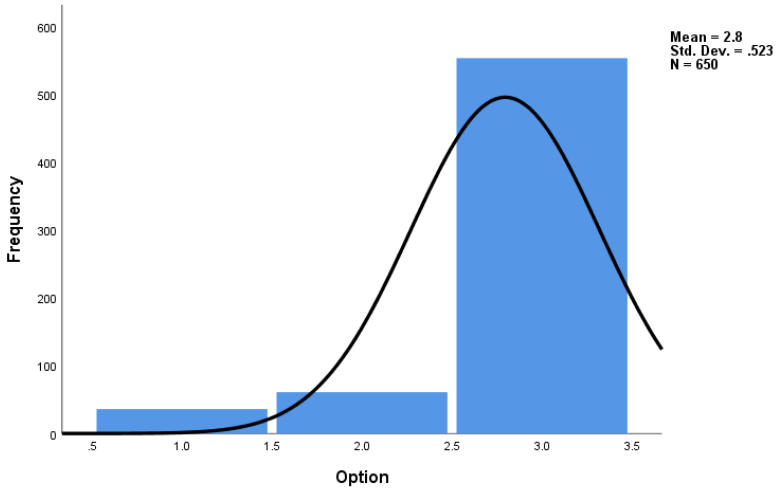
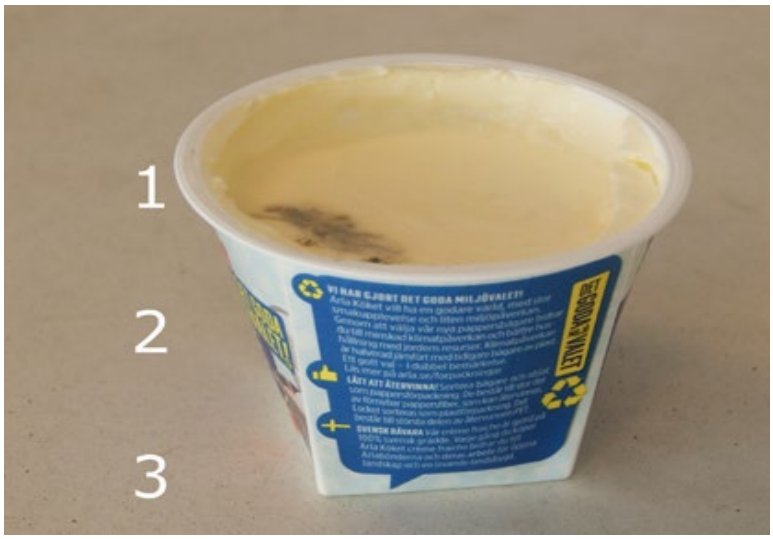


Figure 19. Mouldy Béarnaise sauce with number-markings for participants to indicate where would discard the sauce, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

The majority of the participants, 85%, answered that they would completely discard the béarnaise sauce when it has mould in it (Figure 19). At mark 1, 6% would scoop of the mould and 9% would take away to mark 2. The normal distribution curve illustrates that the most of the participants would discard the sauce. The chi-square test showed variance between gender and T-test showed no significant difference in responses depending on gender

A.



B.

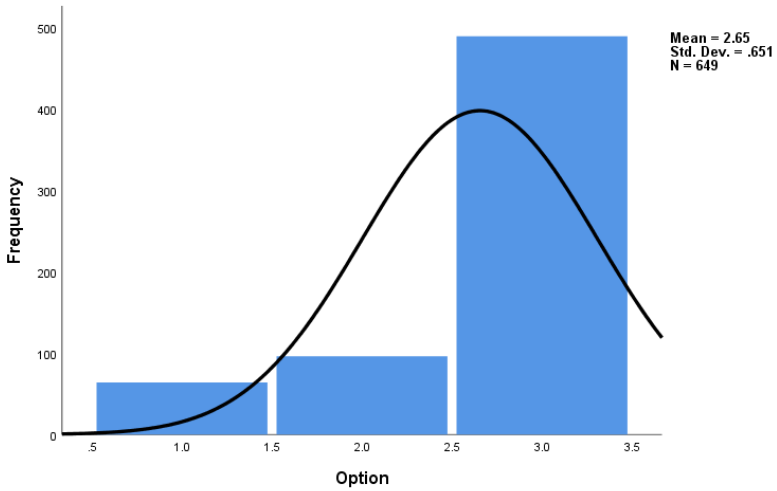


Figure 20. Mouldy crème fraiche with number-markings for participants to indicate where would discard the sauce, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

Approximately 75% of participants would discard the crème fraiche, while about 10% would remove the mould at mark 1 and then consume the rest (Figure 20). The normal distribution curve in Figure 20B shows that the tendency is to discard the product completely. The chi-square test showed that equal variance between sexes could be assumed and the T-test showed that there were significant differences between genders. The mean value for men was about 2.5, whereas for women the mean was approximately 2.7, that is, a tendency to discard the product.

A.

B.

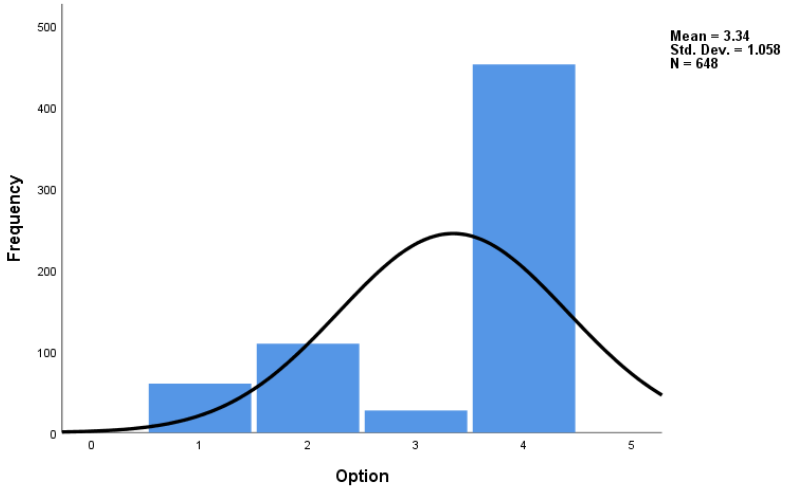


Figure 21. Mouldy salsa with number-markings for participants to indicate where would discard the salsa, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

Of the participants, about 70% would discard the salsa, 9% would take away only the mouldy part, and about 17% to mark 2 (Figure 21). Although the spread of responses does not follow the normal distribution curve, the overall trend seems to be to discard the salsa completely. The t-test did not show any significant differences between gender responses.

A.

B.

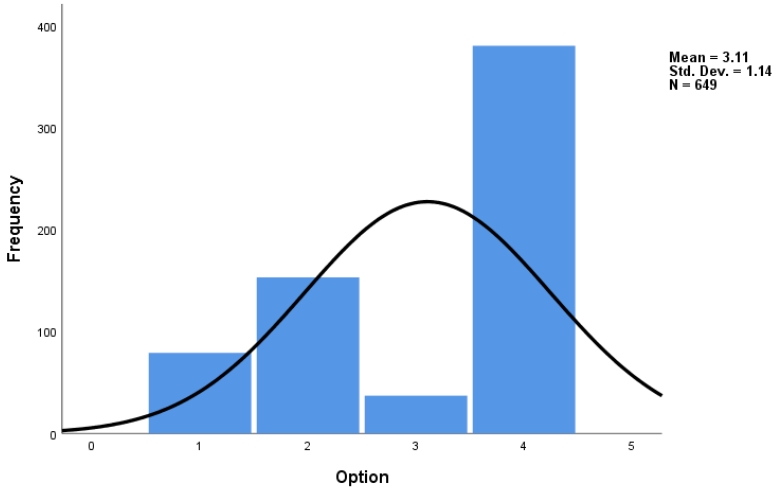


Figure 22.Mouldy apple sauce with number-markings for participants to indicate where would discard the sauce, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

Apple sauce was discarded by about 59% of the participants, and only 12% would discard at mark 1 (Figure 22). About 24% would discard to mark 2, equivalent to about 2 cm of the product. The Person Chi-square test showed equal variance between the genders and the T-test showed significant differences between the genders. Looking to the mean values, men had a lower mean value (2.8) than women (3.2), that is, women had a greater tendency to discard the apple sauce. The

normal distribution curve in Figure 22B showed that, despite a majority of participants choosing to discard the sauce completely, there was quite a large spread in the responses which displaced the curve against discarding the apple sauce.

A.

B.

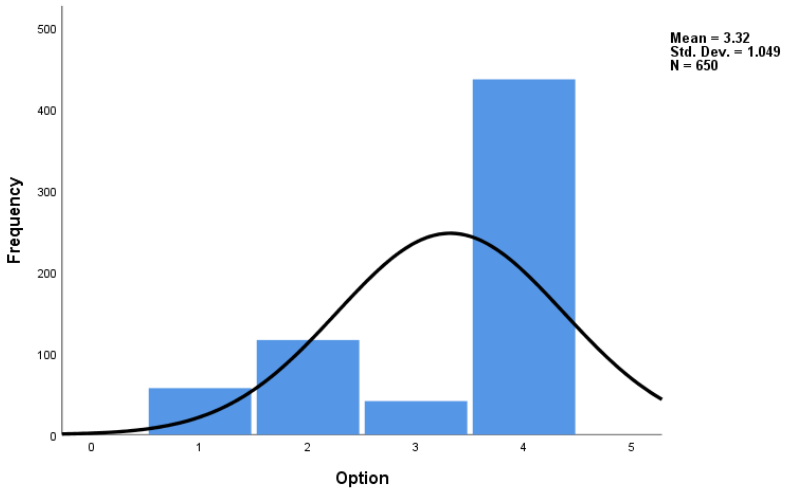
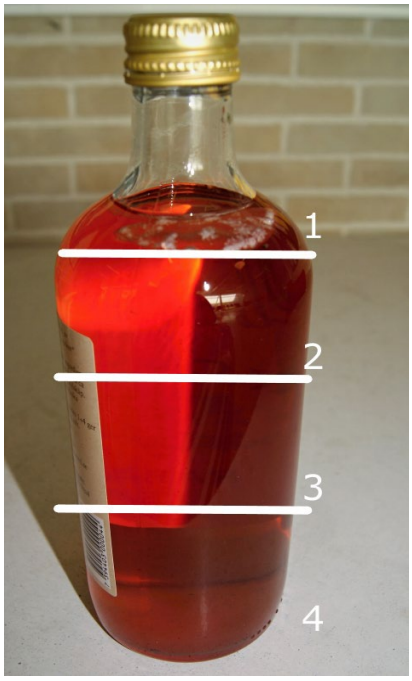


Figure 23. Mouldy Turkish yoghurt with number-markings for participants to indicate where would discard the yogurt, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

A minority of the participants (only 9%) would take away the mould at mark 1, about 18% to mark 2, and the majority (67%) would discard the product completely (Figure 23). However, comparing the responses with the normal distribution curve shows that the participants would handle the product quite differently. The Pearson

chi-square test showed variance between the genders and the T-test showed no significant differences between the gender responses.

A.



B.

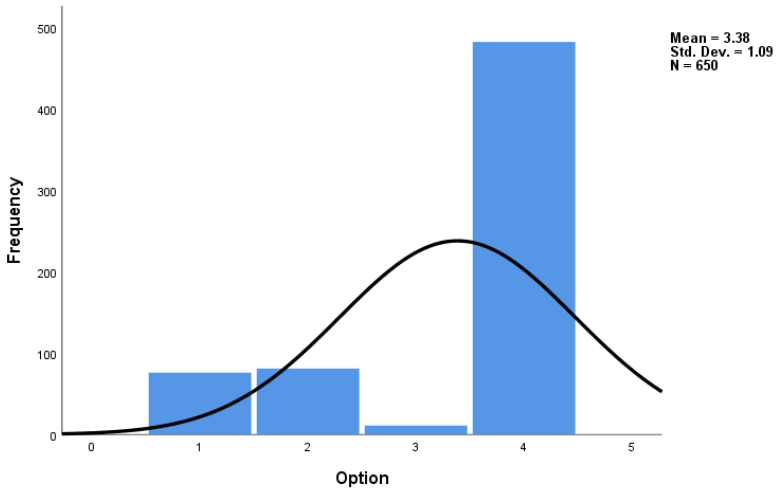


Figure 24. Mouldy squash (concentrated fruit cordial) with number-markings for participants to indicate where would discard the squash, as shown in A. B. shows the frequency of participant responses to image A, with the normal distribution curve for responses shown as a black line.

Approximately 74% of the precipitants answered that they would completely discard the squash (Figure 24). Around 12% would discard to mark 1 and a similar proportion to mark 2; a few the participants would discard to mark 3. The normal distribution curve in figure 24B show the tendency towards discarding the squash completely, yet the responses were not evenly spread under the curve.

The chi-square test showed that not equal variance can be assumed, and this resulted in that the T-test showed a significance at 1.6%, that is, a significant variance in how the genders handle squash was demonstrated. Of the men, 21% would discard at mark 1 whereas only 10% of the women would do the same. However, an equal proportion of men and woman would discard to mark 2, approximately 12.5%.

When looking at all semi-liquid or liquid products normal distribution curve there are similarities. The majority of the participants would discard the products, that is, the curve is shifted towards the discarding option. Of the participants who would partially take away the product, most choose mark 2, about 2 cm from where the mould is situated. A study to see how mycotoxins diffuse in apple jam and cream fraiche during chilled storage showed that biologically active compounds were found when mould was present in food (Olsen *et al.*, 2019). There are several factors that seems to affect the distribution of toxin in a product (storage temperature, fungal species, properties of the food and size of toxin molecules). Despite small colonies a range of toxicological compounds can be formed. The researchers concluded that there are difficulties to give certain advice on handling the food items other than advising the consumer to discard the product. The SFA recommends discarding these types of products with one exception being jam with 33g sugar/100 g jam (Rosengren, 2017), as the water activity would be sufficiently low to inhibit mycotoxin production. Of the semi-liquid products presented in the survey, the apple sauce was the one that had the most differences in responses, and this might be related to the recommendation from the SFA.

4.2.3. Age differences in survey

The survey data was analysed with respect to age differences in how the questions were answered. The data was tested via Person chi-square test to examine if equal variance could be assumed or not when doing the T-test.

There were several questions in the survey that showed no significant differences between the age groups and how they handled the mouldy products. The questions with no differences were those for liver pâté, peach, pear, taco salsa and Turkish yoghurt. There were two questions (carrot and squash) where there was a significant difference between age group over 65 and all other age groups, see appendix 4. It is important to mention is that there is an underrepresentation in group (over 65) compared to the other age groups and that could have affected the results. In the following section, data where there were differences will be presented for the whole table.

Table 4. Age-based differences in response to the statement "If I take away the mouldy part, I can still eat the rest", P-values showing significant differences are highlighted.

Age	18-25	25-35	35-50	50-65	Over 65
18-25		0.228	0.001	0.017	0.003
25-35			0.004	0.118	0.015
35-50				0.224	0.629
50-65					0.179
Over 65					

If it is safe to eat a product if the mouldy part is discarded showed differences between participants depending on age. In Table 4, there are significant differences between the participants in two age groups (18-25 and 25-35) to the rest of the participants. There were about 17% of the participants in age group 18-25 that disagreed with the statement compared with 44% respectively 41% in age group 35-50 and 50-65. That indicate that participants in age group 18-25 disagreed less with the statement.

Table 5. Age-based differences in response to the statement "If I heat the mouldy product I can eat it" P-values showing significant differences are highlighted.

Age	18-25	25-35	35-50	50-65	Over 65
18-25		0.444	0.019	0.850	0.087
25-35			0.001	0.504	0.156
35-50				0.009	0.626
50-65					0.079
Over 65					

In Table 5, the participants in age group 35-50 answered differently from three age groups; 18-25, 25-35 and 50-65, regarding if a mouldy product could be consumed after heating. In the age group 35-50 there were about 2% that think that after heating a mouldy product it can be consumed, compared to about 3% and 4% in age groups 18-25 and 50-65, respectively.

Table 6. Age-based differences in proposed handling of the mouldy béarnaise sauce. P-values showing significant differences are highlighted.

Age	18-25	25-35	35-50	50-65	Over 65
18-25		0.135	0.018	0.002	0.013
25-35			0.147	0.009	0.109
35-50				0.301	0.698
50-65					0.663
Over 65					

There were significant differences in handling of the béarnaise sauce depending on age (Table 6). The 74% of participants in the age group 18-25 chose to discard the béarnaise sauce compared to 88% and 92% in age groups 35-50 and 50-65, respectively.

Table 7. Age-based differences in proposed handling of the mouldy bread. P-values showing significant differences are highlighted

Age	18-25	25-35	35-50	50-65	Over 65
18-25		0.872	0.019	0.185	0.532
25-35			0.001	0.050	0.553
35-50				0.219	0.006
50-65					0.065
Over 65					

The participants in age group 18-25 about 29% would discard the bread compared to age groups 35-50 and 50-65, where about 50% and 46% would discard the bread, respectively (Table 7).

One of the most interesting findings when looking on age differences is that the younger participants (18-25) tended to discard less of some products then the older age categories. This is the opposite trend to that reported by Secondi *et al.* (Secondi *et al.*, 2015) who examined households food waste behaviour in 27 European countries, where they found a significant association between older people and less likelihood to waste food. One hypothesis could be that the awareness of the problem with food waste is more discussed today in the younger population and therefore the results in the current survey reflect this trend.

4.3. Are moulds from foods dangerous or not for consumers

In this following section the fungal identification of the spontaneously mouldy food products from people's home are presented. The result gives a snapshot of what species of mould can be present in Swedish households.

Table 8. Identification of mould present in foods from Swedish households

Type of food and appearance of spoilage	Fungus isolated	Comment
Bread		
Coarse bread, green spots	*Penicillium palitans, Penicillium solitum*	*P. palitans* common on food, including bread, and in indoor environments. Produces cyclopiazonic acid. *P. solitum* common on food and indoor environments. No

		important mycotoxins (Samson et al., 2010)
White bread A, greenish spots	*Aspergillus neoniger*	Closely related to the common foodborne species, *A. niger.* First isolated from environmental samples (marine sponge, Venezuela; desert sand, Namibia). No known mycotoxins (Varga et al., 2011)
White bread B, black spots	*Rhizopus probably stolonifer*	Food and indoor environments, commonly air-borne (Samson et al., 2010)
White bread C, green spots	*Talaromyces rugulosus*	Food and indoor environments, commonly air-borne (Samson et al., 2010)
White bread samples D,E, F and G, green or white spots	*Penicillium melanoconidium*	Barley, wheat, rye, oats, rice (Frisvad & Samson, 2004)

Cheese and dairy products

Type of food and appearance of spoilage	Fungus isolated	Comment
Cheese spread, shrimp flavour, green spots	*Penicillium bialowiezense*	Various foods, including yogurt, bread, also air in factories (Frisvad & Samson, 2004)
Hard cheese A, green spots	*Mucor racemosus*	Food and indoor environments (Samson et al., 2010)
Hard cheese B, green spots	*Penicillium commune, Penicillium roqueforti*	*P. commune*: Food and indoor air; especially on cheese, dried meat, dried fish and nuts. *P. roqueforti*: common in temperate regions; used in

		blue cheese production. (Samson et al, 2010)
Sour cream, various greenish spots	*Penicillium solitum, Penicillium roqueforti, Mucor plumbeus*	*P. solitum* common on food and indoor environments. No important mycotoxins. (Samson et al., 2010) *P. roqueforti*: see above *M. plumbeus*: Food and indoor environments, commonly air-borne (Samson et al., 2010)

Fresh vegetables and fruits		
Type of food and appearance of spoilage	Fungus isolated	Comment
Apple, green spots	*Penicillium expansum*	Food and indoor environments, especially on pomaceous and stone fruits where it produces a destructive rot. Produces the mycotoxin, patulin (Samson et al., 2010)
Apricot, greenish spots	*Rhizopus probably stolonifer*	Food and indoor environments, commonly air-borne (Samson et al., 2010)
Asparagus, black spots	*Penicillium venetum*	Asparagus, also iris, hyacinths (Frisvad & Samson, 2004) Yeast and bacteria also isolated but not identified
Avocado, green spots	*Alternaria probably alternata*	Isolated from nuts, pomaceaous and stone fruit (Samson et al., 2010)
Cabbage, black spots	*Wickerhamomyces onychis* (yeast)	Previously isolated from fermented plant products, e.g. tomato, grape must

		(Bah et al., 2019; Cioch-Skoneczny et al., 2020) Motile bacteria also isolated but not identified.
Carrot, white spots	*Penicillium venetum*	See above. Bacteria also isolated but not identified.
Beetroot, white spots	*Plectospherella curcumina*	Associated with sugar beets, usually as part of healthy microbiome (Kusstatscher, P et al., 2019), but can cause rots in melons (Carlucci et al., 2012)
Kiwi, black and white spots	*Rhizopus probably koreanus*	Previously isolated from a persimmon fruit (Li et al., 2016)
Melon, grey-green spots	*Botrytis cinerea*	Food and indoor. ”Grey-mould”, capable of spoiling various types of fruits. (Samson et al., 2010)
Nectarine, green spots	*Geotrichum candidum*	Food and indoor. Isolated from a variety of substrates e.g. water, soil, air, various fruits. (Samson et al., 2010)
Pear, green spots	*Penicillium expansum*	See above
Physalis, greenish spots	*Penicillium glabrum*	Food and indoor environments, including fruits. Often detected in indoor air (Samson et al., 2010)
Tomato, black spots	*Rhizopus probably koreanus*	See above

Sauces and conserves (liquid / semi-liquid)		
Type of food and appearance of spoilage	Fungus isolated	Comment

Ajvar, white spots	*Torulaspora delbrueckii* (yeast)	Common food and beverage spoilage yeast (Kurtzman et al., 2011)
Pesto, green spots	*Penicillium brevicompactum*	Food and indoor environments, including indoor air (Samson et al., 2010)
Jalapenos (pickled), white spots	*Penicillium glabrum, Cladosporium probably near tenuissima*	*P. glabrum*: Food and indoor, including fruits. Often detected in indoor air (Samson et al., 2010) *Cladosporium* sp.: Certain species-complexes are often associated with indoor environments and contaminants of food products (Samson et al., 2010)
Kimchi (pickled), green spots	*Penicillium bialowiezense*	Various foods, including yogurt, bread, also air in factories (Frisvad & Samson, 2004)
Raspberry jam, green spots	*Penicillium italicum*	Common on foods (Samson et al., 2010)
Fresh yeast		
Type of food and appearance of spoilage	Fungus isolated	Comment
Fresh yeast, green spots	*Penicillium italicum*	Common on foods (Samson et al., 2010)

In both pear and apple, *Penicillium expansum* was identified and this finding is well-supported by the earlier studies on these products. *P. expansum* can produce the mycotoxin patulin that is regulated in European Union. Researchers from China looked at distribution of *Penicillium* and patulin in pears infected with *P.*

expansum and found that the highest amount of patulin was in the lesion itself and further away, the concentration of patulin was lower (Dong-mei *et al.*, 2017). When the lesion had size of 20 mm in diameter, patulin could be measured 10 mm from the lesion a residual concentration of 0.0882±0.0116 mg/kg.

The avocado was identified to have *Alternaria* isolate but it could not be determined which species. It could be a small risk for mycotoxin production if the species was *A. alternata* or other toxin producing species. The Alternaria-toxins are however not yet regulated in EU as they are considered not to be very dangerous toxins.

The majority of the mould species found in the spontaneously mouldy food stuffs would generally not be considered to be harmful to human and can be seen as spoilage moulds. So, it might not be a big risk for the consumers that choose to scrape/cut off partially a mouldy product. However, as mentioned before, these results are just a snapshot so more research in this area would be necessarily. The majority of the mycotoxin producing moulds are found earlier in the food chain (e.g. *Fusarium* toxins produced in grains pre-harvest) and are controlled and regulated according to European Union.

4.4. Final discussion and conclusion

It is difficult for the food authorities to formulate recommendation for the handling of mouldy food products. The recommendations should be based on worst-case scenario experimental setups, according to Coton and Dantigny (2019). Furthermore, it was not clearly stated what the recommendations in the United States are based on, compared with the SFA who make their summary of scientific background for their recommendations available online. Also there is a problem to have general recommendations, since products comes with different formulations, for example, cream fraiche is sold with both light and regular fat content, and that can affect how the mycotoxin distributes in the product (Olsen *et al.*, 2019). It could be argued that recommendations to consumers must be easy to understand and easy to apply in households. For example, the recommendation from the SFA regarding handling of jam (33g sugar/100g product) might be too advanced, since it could be rather a habit that you take away mould from jams or not, instead of looking at the sugar content of the jam and then making a decision on how to handle it. For future surveys it would be of interest to also ask the participants how they would remove the mould from the product (which utensils they would use), if they do so.

Swedish SFA recommendation for apple and bread are of interest to compare. For the bread, the consumer is advised to discard a bread completely if it has started to become mouldy. As discussed in section 4.4.2, this advice is based on a few studies

from the late 1970s and could in one sense be seen as very cautious. In a more recent study (Sulyok *et al.*, 2010) the scientists found that certain mycotoxins known to be produced in the cereals in the field were evenly distributed in the product and not in higher concentration at the mouldy spot and that suggests that rather mycotoxin-contaminated grain was used for bread making; other mycotoxins produced probably by moulds growing directly on the bread were, as expected, more concentrated at the mouldy spot, and some toxins had diffused further into the bread. However, this indicates that some of the main mycotoxin risks from bread should be handled at the farm and flour milling stages, to avoid mycotoxin-contaminated grain from entering the food chain. The consumer does have a choice to partially or completely discard mouldy bread slice(s), however there are fewer studies to inform this choice. The SFA acknowledges that their advice is based on the "precautionary principle" because if the contaminating mould produces aflatoxin, this is a highly toxic mycotoxin (Olsen & Svanström, 2017). Those authors also note that "For the purposes of minimising bread waste, more thorough studies should be done before we can advise on how to cut off the mouldy portion."

In contrast, there are several recent studies of patulin present in both apples and pears and how the mycotoxin is traveling (migrating) in the product (Touhami *et al.*, 2018; Dong-mei *et al.*, 2017). The main advice from the SFA to cut off the rotten part and 2 cm around it only applies to apples and not other fruit with small rotten parts, because pears has been showed to contain high amounts of patulin in healthy fruit flesh (Olsen & Svanström, 2017). Here, the advice is not based on the "precautionary principle" in the same way as for bread, but rather on the available data, which shows that in apples, but not other fruits, the migration of patulin from small rots does not spread extensively throughout the fruit. For future surveys, it would have been of interest to also include a mouldy apple to see if there is a difference between pear and apple in the way the consumers handle the fruits, to be able to understand consumer behaviour better.

The United Nation has two goals SDG 2 (zero hunger) and SDG 12 (responsible consumption) that might compete with each other. One goal is that all people should consume safe food and the other goal is for reduction of waste in the food supply chain. To achieve reduction at consumer level where mould is one of the most common causes for food waste, more research is needed. What kind of moulds that are present and how the recommendations should be formulated regarding whether to consume or discard the products has to be examined more. The advice from food authorities in the world might need to be updated and it would be desirable with more similar advice between countries. The recommendation regarding handling of products should be based on scientific studies in order not to risk consumer's health.

In the survey, the men were underrepresented, and for future research, it would be preferable with a more even distribution of the genders. There were some attempts on weighing the results, but because of limited time, that was not successful. Instead, the gender was tested against each other statistically with T-test and in most of the questions there were no significant differences between the genders. Where significant differences were observed, the tendency was for men to discard less of the mouldy product.

The age category over 65 was quite underrepresented due to Covid-19 and the recommendation from the Swedish government to minimise social contacts, which influenced how the survey was spread. Therefore, for future studies it would be interesting to have a better representation of that age category to get a better overview on how the Swedish population handles mouldy foods.

Regarding the snapshot of moulds present in Swedish households, there were no analyses on how far into the product metabolites from the mould had migrated. For future research, it would be good to analyse if, for example, the *Penicillium expansum* isolate had produced patulin in the pear and to what extent. It would also be of interest to study other moulds that are considered as "safe" since they are not known to produce any mycotoxin that are regulated in the European Union. Even if their metabolites are not regulated today, it does not necessarily mean that these compounds are not biologically active in humans; rather there is need for more studies on the moulds and toxicity of their secondary metabolites.

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Appendix 1

Populärvetenskaplig summering

Världens population ökar vilket leder till ett ökat behov utav mat. Det är beräknat att en tredjedel av all mat som produceras kastas, vilket innebär ett stort svinn. Förenta nationerna har utvecklat 17 globala mål för en hållbar utveckling. Ett mål är ”ingen hunger” (SDG 2) som strävar efter att 2030 skall alla på jorden kunna äta sig mäta på säker och näringsrik mat. Ett annat mål ”ansvarsfull konsumtion och produktion” (SDG 12) syftar till att vi ska producera hållbar mat och bland annat minska matsvinn på konsumentnivå med 50% år 2030.

Mögel är en vanlig orsak till matsvinn. Vissa mögelarter producerar även ämnen som är skadliga för oss människor, så kallade mykotoxiner. Genom Europeiska unionens direktiv sker reglering på vissa av dessa mykotoxiner vilket innebär att producenter och företag måste kontrollera att produkter inte överskrider gränsvärden. I och med att en av de vanligaste orsakerna till matsvinn på konsumentnivå är mögel så behövs det mer kunskap om vilka typer av mögel som förekommer i hemmet och om dessa mögel är farliga. Det behövs även kunskap om hur konsumenter hanterar mögliga livsmedel i hemmet då detta är begränsat i dagsläget.

Denna studie syftade till att utvärdera konsumenters kunskap och relation till mögliga livsmedel. För att undersöka konsumenters hantering av möglig mat i hemmet skickades en enkät, till stor del bestående av bilder, ut via sociala medier. Målet var att få en jämn fördelning mellan ålder och kön och möjliggöra ett stort antal deltagare. Totalt medverkade 650 svenska invånare i enkäten som tillsammans har givit en tydligare bild av hur svenskar hanterar mögliga livsmedel. Det var inte en jämn fördelning mellan könen så för att kunna använda informationen så utfördes statistiska analyser. Det var tänkt att enkäten skulle delas ut i person men på grund av restriktionerna i och med Covid-19 blev detta inställt. Det kan ha påverkat underrepresentationen i åldersgruppen över 65.

79% av deltagarna ansåg att möglig mat kunde vara farligt och avstod helt konsumtion av en möglig produkt. Bland bilderna på mögliga produkter i enkäten så kastade majoriteten av deltagarna tacosås, leverpastej, cream fraîche, turkisk yoghurt och saft. Andra produkter så som bröd, persika, päron, morot, ost och äppelmos hanterade deltagarna olika. Av produkterna som presenterades i enkäten fanns det bara en produkt där livsmedelsverket specificerat särskilda rekommendationer och det var ost. Vid mögel på ost kan konsumenten skära bort 2

centimeter av det utsatt området. Viktigt är att använda rena redskap som inte har varit i kontakt med möglet då det annars finns en risk att möglet sprider sig. För övriga livsmedel i enkäten rekommenderas konsumenten att kasta hela produkten vid uppstod av mögel. När det gäller päron, där ca. 40% av deltagarna tar bort delar av produkten vid mögel, finns en risk för att utsättas för det reglerade toxinet patulin. Detta trots att mögliga delen tas bort. Forskning har visat att toxinet även förekommer i delar av päronet som inte är visuellt mögliga.

Det gjordes även en insamling av 31 olika produkter som spontant möglat i hemmet. Dessa mögel blev identifierade och mögelarter bestämdes. Det visade sig att av produkterna som blev insamlade hade två produkter (päron och äpple) ett mögel *Penicillium expansum* som kan producera patulin, vilket är reglerat i EU. I övriga produkter återfanns ingen mögelart som kan producera toxin som är reglerat. Detta innebär inte att man kan säga att produkterna är säkra utan snarare att det inte finns tillräckligt mycket forskning inom området.

Slutsatsen som man kan dra av denna studie är att det är svårt för livsmedelsverket att ge rekommendationer för hantering av mögliga livsmedel. Dels verkar det som att konsumenter inte söker upp information om hur de ska hantera produkter som möglat, men även forskning på vilka typer av mögel som förekommer i hemmet är begränsad och om dessa mögel kan producera och sprida mykotoxiner. Det är viktigt att rekommendationerna baseras på forskning för att minimera exponeringen av skadliga ämnen och för att kunna ge säkra rekommendationer.

Appendix 2

Survey on following pages

1.

Gender:

- ☐ Woman
- ☐ Man
- ☐ Do not wish to respond

Living in Sweden?

- ☐ Yes
- ☐ No

Age:

- ☐ under 18 years
- ☐ 18-25 years
- ☐ 25-35 years
- ☐ 35-50 years
- ☐ 50-65 years
- ☐ over 65

In which sector are you established?

- ☐ Agricultural sector
- ☐ Education
- ☐ Authority
- ☐ Health care
- ☐ Manufacturing industry
- ☐ Food business
- ☐ Design and construction technique
- ☐ Retail
- ☐ Unemployed
- ☐ Economic and administration
- ☐ IT and telephony
- ☐ Hotel and restaurant services
- ☐ Senior citizen
- ☐ Student
- ☐ Other

2.

How often do you shop groceries?

- ☐ 1 time/week
- ☐ 2-3 times/week
- ☐ More then 3 times/week
- ☐ Less then 1 time/week

Do you throw away food in your household?

- ☐ Yes
- ☐ No

Which type of product/products is wasted? (multiple options are possible)

- ☐ Fruit and vegetables
- ☐ Dairy products
- ☐ Charcuteries
- ☐ Ready-to-eat food
- ☐ Meat
- ☐ Bread and pastery
- ☐ Cereal products (example: rice and pasta)
- ☐ Jam & Juices
- ☐ Sauces
- ☐ Left overs
- ☐ Other

Why is the product discarded? (multiple options are possible)

- ☐ Best-before-date has passed
- ☐ The product taste/smell differently
- ☐ The product has mould
- ☐ The product has dried/change texture
- ☐ Other

4. Answer the five statements

	Agree fully	Agree	Neutral	Do not agree	Do not know
If I take away the mouldy part of the product I can still eat the rest	☐	☐	☐	☐	☐
Mould is not dangerous so I can eat the product	☐	☐	☐	☐	☐
If I wash the product it can still be eaten	☐	☐	☐	☐	☐
If I heat the mouldy product I can eat it	☐	☐	☐	☐	☐
If the product are mouldy I have to discard the whole product	☐	☐	☐	☐	☐

5.

You will now see 12 pictures on products with moulds. How would you handle the different foods stuff?

One slice of bread has mould, I would:

☐ 1 - discard the mouldy slice then eat the rest of the product.

☐ 2 - discard the mouldy slice, plus one more, then eat the rest of the product.

☐ 3 - discard to mark nr 3 then eat the rest.

☐ 4 - discard the whole product.

6.

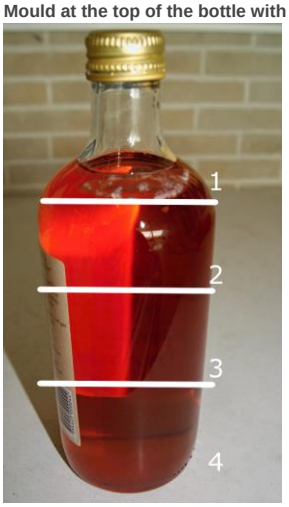
The Pâté has mould on the surface, I would:

☐ 1 - discard the part that has mould then eat the product.

☐ 2 - discard to mark nr 2 then eat the product.

7.

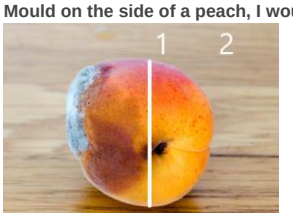
Mould at the top of the bottle with lemonade, what would you do?



- ☐ 1 - discard the mouldy part and consume the lemonade.
- ☐ 2 - pour out lemonade to mark nr 2 and then consume the lemonade.
- ☐ 3 - pour out lemonade to mark nr 3 and then consume the lemonade.
- ☐ 4 - discard the whole lemonade.

8.

Mould on the side of a peach, I would:



- ☐ 1 - discard half of the peach and then eat the rest
- ☐ 2 - discard the whole peach

9.

The sauce has mould on top, I would:

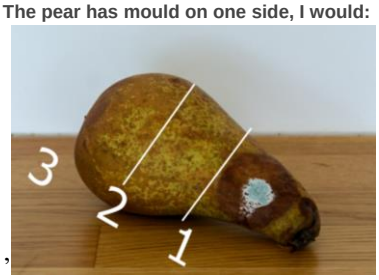
- ☐ 1 - discard the mouldy part then eat the product.
- ☐ 2 - discard half of the can and then eat the rest.
- ☐ 3 - discard the whole product.

10.
The Crème Fraiche has mould on the top, what do you do?

- [ ] 1 - discard the mouldy part and then use the rest.
- [ ] 2 - discard half of the product and then use the rest.
- [ ] 3 - discard the whole product.

11.
The pear has mould on one side, I would:

,



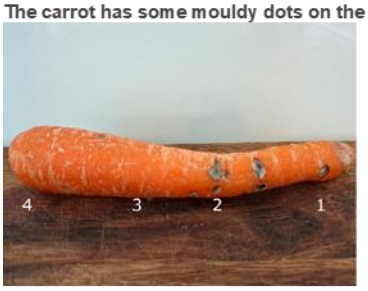
- [ ] 1 - cut of the mouldy part and then eat the pear.
- [ ] 2 - cut of half of the pear and then eat the product.
- [ ] 3 - discard the whole pear.

12.
The salsa has mould on the top of the jar, I would:

- [ ] 1 - discard the mouldy part and then use the rest.
- [ ] 2 - discard to mark nr 2 then eat the product.
- [ ] 3 - discard to mark nr 3 and then eat the product.
- [ ] 4 - discard the whole product.

13.

The carrot has some mouldy dots on the surface, I would:



- ☐ 1 - remove the peel and eat the product.
- ☐ 2 - remove to mark nr 2 and then eat the product.
- ☐ 3 - remove to mark nr 3 and then eat the product.
- ☐ 4 - discard the whole product.

14.

The cheese has mould on the upper surface, I would:

- ☐ 1 - discard the mouldy part and then eat the rest.
- ☐ 2 - discard to mark nr 2 and then eat the product.
- ☐ 3 - discard the whole product

15.

The apple sauce has mould on the top of the jar, I would:

- ☐ 1 - discard the mouldy part and then eat the rest of the product.
- ☐ 2 - discard to mark nr 2 and then eat the rest of the product.
- ☐ 3 - discard to mark nr 3 and then eat the rest of the product.
- ☐ 4 - discard the whole product.

16.
The yoghurt has a mould on the top of the can, I would:

- [ ] 1 - discard the mouldy part and then eat the product.
- [ ] 2 - discard to mark nr 2 and then eat the product.
- [ ] 3 - discard to mark nr 3 and then eat the product.
- [ ] 4 - discard the whole product.

17.

Do you search for information if you have mouldy food products at home?

- [ ] Yes
- [ ] No

Is it easy to find information about how to handle foods stuff that are mouldy?

- [ ] Yes
- [ ] No
- [ ] Do not know

Thank you for your time and that you answered this survey.
For more information and recommendation about how to handle mouldy foods visit the Swedish National Food Agency at their homepage: www.livsmedelsverket.se

Appendix 3

	Group Statistics						
	Sex	N	Mean	Std. Deviation		T-test Sig. (2-tailed)	Asymptotic significance (chi-square)
Mould is not dangerous so I can eat the product	Woman	552	3.72	.643	Equal variances assumed	.865	.886
	Man	95	3.71	.634	Equal variances not assumed	.864	
If I wash the mouldy product it can still be eaten	Woman	552	3.80	.635	Equal variances assumed	.707	.144
	Man	95	3.77	.691	Equal variances not assumed	.724	
If I heat the mouldy product I can eat it	Woman	552	3.96	.386	Equal variances assumed	.644	.141
	Man	95	3.98	.483	Equal variances not assumed	.694	
If the product are mouldy I have to discard the whole product	Woman	552	2.97	1.155	Equal variances assumed	.136	.007
	Man	95	3.16	1.045	Equal variances not assumed	.112	
If I take away the mouldy part of the product I	Woman	552	2.86	1.046	Equal variances assumed	.020	.257
	Man	95	2.59	1.016	Equal variances not assumed	.019	

can still eat the rest							

	Group Statistics						
	Sex	N	Mean	Std. Deviation		T-test Sig. (2-tailed)	Asymptotic significance (chi-square)
Bread	Woman	552	2.61	1.257	Equal variances assumed	.004	0.017
	Man	95	2.20	1.285	Equal variances not assumed	.005	
Pâté	Woman	552	2.82	.480	Equal variances assumed	.004	0.04
	Man	95	2.65	.632	Equal variances not assumed	.018	
Squash	Woman	552	3.43	1.048	Equal variances assumed	.005	0.043
	Man	95	3.09	1.281	Equal variances not assumed	.016	
Peach	Woman	552	1.60	.490	Equal variances assumed	.172	0.385
	Man	95	1.67	.471	Equal variances not assumed	.162	
Béarnaise sauce	Woman	552	2.81	.500	Equal variances assumed	.026	0.241
	Man	95	2.68	.640	Equal variances not assumed	.064	
Cream Fraiche	Woman	551	2.69	.618	Equal variances assumed	.003	0.002
	Man	95	2.47	.797	Equal variances not assumed	.014	
Pear	Woman	552	2.29	.733	Equal variances assumed	.394	0.224
	Man	95	2.22	.814	Equal variances not assumed	.430	
Salsa	Woman	550	3.37	1.046	Equal variances assumed	.146	0.126
	Man	95	3.20	1.126	Equal variances not assumed	.170	

Carrot	Woman	551	2.72	1.095	Equal variances assumed	.415	0.045
	Man	95	2.82	1.194	Equal variances not assumed	.444	
Hard cheese	Woman	552	1.86	.664	Equal variances assumed	.953	0.049
	Man	95	1.86	.780	Equal variances not assumed	.958	
Apple sauce	Woman	551	3.16	1.111	Equal variances assumed	.004	0.027
	Man	95	2.80	1.260	Equal variances not assumed	.010	
Turkish yoghurt	Woman	552	3.35	1.020	Equal variances assumed	.128	0.025
	Man	95	3.17	1.200	Equal variances not assumed	.176	

H0 – the handling is the same between the sex
In yellow marks the H0 is rejected
Yellow – significant differences between groups
Non yellow – not possible to say if there is a difference between groups.

Look into the variance by doing chi-square test to see if there is a variance in the sample group, choose between 2-tail depending if it is an assume equal variance or assume not equal variance.

Appendix 4

Down under the table with the result from the T-test to compare if there are any age differences in the answer. Were the p-value being less than 0.05 there are a significant difference between the different age categories in answering of the question.

Question 1 - If I take away the mouldy part i can still eat the rest					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,228	0,001	0,017	0,003
25-35			0,004	0,118	0,015
35-50				0,224	0,629
50-65					0,179
Over 65					
Mould is not dangerous so I can eat the product					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,724	0,853	0,236	0,262
25-35			0,500	0,052	0,299
35-50				0,246	0,15
50-65					0,017
Over 65					

If I wash the mouldy product it can still be eaten

Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,029	0,073	0,362	0,238
25-35			0,728	0,129	0,678
35-50				0,289	0,851
50-65					0,592
Over 65					

If I heat the mouldy product I can eat it

Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,444	0,019	0,850	0,087
25-35			0,010	0,504	0,156
35-50				0,009	0,626
50-65					0,079
Over 65					

If the product are mouldy I have to discard the whole product

Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,688	0,069	0,234	0,357
25-35			0,004	0,038	0,178
35-50				0,445	0,645
50-65					0,951
Over 65					

Bread					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,872	0,019	0,185	0,532
25-35			0,001	0,050	0,553
35-50				0,219	0,006
50-65					0,065
Over 65					

Liver pâté					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,612	0,417	0,459	0,622
25-35			0,078	0,099	0,879
35-50				0,933	0,227
50-65					0,250
Over 65					

Squash					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,411	0,757	0,041	0,000
25-35			0,575	0,119	0,000
35-50				0,052	0,000
50-65					0,013
Over 65					

Peach					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,548	0,184	0,768	0,657
25-35			0,298	0,704	0,289
35-50				0,189	0,090
50-65					0,440
Over 65					

Bearnaise sauce					
Age	18-25	25-35	35-50	50-65	Over 65

18-25		0,135	0,018	0,002	0,013
25-35			0,147	0,009	0,109
35-50				0,301	0,698
50-65					0,663
Over 65					

Cream Fraiche					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,228	0,353	0,212	0,820
25-35			0,092	0,031	0,549
35-50				0,702	0,552
50-65					0,380
Over 65					

Pear					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,293	0,066	0,221	0,090
25-35			0,256	0,773	0,317
35-50				0,421	0,955
50-65					0,461
Over 65					

Taco Sauce					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,763	0,197	0,911	0,587
25-35			0,157	0,802	0,360
35-50				0,118	0,074
50-65					0,466
Over 65					

Carrot					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,482	0,374	0,031	0,004
25-35			0,747	0,041	0,005

35-50				0,128	0,014
50-65					0,186
Over 65					

Cheese					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,852	0,172	0,424	0,295
25-35			0,129	0,205	0,162
35-50				0,011	0,016
50-65					0,659
Over 65					

Apple Sauce					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,526	0,308	0,855	0,114
25-35			0,566	0,286	0,014
35-50				0,133	0,006
50-65					0,100
Over 65					

Turkish yoghurt					
Age	18-25	25-35	35-50	50-65	Over 65
18-25		0,872	0,322	0,390	0,882
25-35			0,115	0,159	0,980
35-50				0,852	0,262
50-65					0,318
Over 65					