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Salt-roasting of snack pellets

A study on the effects of a novel processing technique on product quality attributes and acrylamide content

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Salt-rostning av snack pellets
En studie om effekterna av en ny bearbetningsteknik på attribut för produktkvalitet och akrylamidinnehåll

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Sammanfattning

Snacks förknippas ofta med chips och olika typer av puffade produkter med en karakteristisk textur. Snacks-produkter har normalt ett högt innehåll av kalorier med ett lågt innehåll av näringsämnen och uppfattas därför som ohälsosamma av många konsumenter. Utöver ett lågt näringsinnehåll kan vissa snacksprodukter även vara en källa till akrylamid som klassificerats som ett cancerframkallande ämne av den Europeiska myndigheten för livsmedelssäkerhet (EFSA). Den växande efterfrågan på hälsosammare snacks har lett till att tillverkare börjar experimentera med nya bearbetningstekniker.

Syftet med studien är att utvärdera produktkvaliteter mellan två olika bearbetningstekniker för snack-pellets. Den mer konventionella expanderingsmetoden fritering i olja jämförs med rostning, som använder salt som värmeledare. För att utvärdera effekten av salt-rostning har mätningar av salt-, fett-, vatten- och akrylamidinnehåll genomförts. Ett triangel-test genomfördes för att bestämma om det finns en skillnad i struktur i produkten beroende på vald process-teknik.

Resultaten indikerar att salt-rostning kan ha en positiv effekt genom att minska akrylamidnivåerna i produkten. Dessutom resulterar salt-rostning i ett snack med ett lågt innehåll av fett. Däremot leder salt-rostning till ett högre saltinnehåll jämfört med fritering. Resultaten från triangel-testet visar att det fanns en signifikant ($p = <0,005$) skillnad mellan friterade och rostade Snack pellets. Den signifikanta skillnaden behöver inte nödvändigtvis vara en nackdel för salt-rostningstekniken. Baserat på paneldeltagarnas kvalitativa kommentarer är de salt-rostade snack pelletsen mindre i storlek samt har en hårade och kompaktare textur jämfört med de friterade. Det är viktigt att påpeka att studiens resultat är begränsade och bör endast betraktas som indikationer.

Ämnesord
Sensorisk analys, Triangel test, Akrylamid, Salt, Fett, Puffade snacks, Snack pellet, Snacks bearbetning

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Expansion of snack pellets
A study on the effect of a novel processing technique on product quality attributes and acrylamide content.

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Abstract

Snacks are often associated with chips and expanded snack products that generally known for their characteristic texture. These products are normally high in calories with a low content of nutrients and are therefore perceived as unhealthy by many consumers. In addition to their low nutrient content, they might be a source of acrylamide, which has been classified as human carcinogen by the European Food Safety Authority. The growing demand for healthier snack foods has led manufactures to begin experimenting with new processing techniques.

The aim of the study is to evaluate product qualities as affected by two different processing techniques of snack pellets. The more conventional expansion method of deep frying in oil is compared to roasting, using salt as a heat conductor. In order to evaluate the effect of salt-roasting, analyses of salt, fat, water and acrylamide content has been carried out. A sensory triangle test was conducted to determine if there is a difference in texture between snacks expanded using the two processing techniques.

Results indicate that salt-roasting may have a positive effect by reducing the level of acrylamide in the product. Furthermore, salt-roasting provides a snack pellet with a lower fat content. However, the salt-roasting technique results in a higher salt content in the snack as compared to deep frying. The results from the triangle test shows that there was a significant ($p=<0.005$) difference between the texture of deep fried and roasted snack pellets. Based on the qualitative commentary of the panelists, the salt-roasted snack pellets are smaller in size and have a harder and more compact texture compared to the deep fried ones. It is important to point out that results of the study are limited and should only be considered as indications.

Keywords
Sensory evaluation, Triangle test, Acrylamide, Salt, Fat, Puffed snacks, Snack pellet, Snack processing,

Abbreviations and explanations of words

WHO - World Health Organization

FAO - Food and Agriculture Organization

JEFSA – Joint European Food Safety Authority

Snack pellet - A non-expanded product made with raw materials that includes extruded cereals, potatoes or vegetable powders

Puffed snack pellet – A processed and expanded snack pellet

Whole Beetroot – included snack pellet from Nature´s Fresh based on beetroot

Whole Broccoli – included snack pellet from Nature´s Fresh based on broccoli

Flor de patat – included snack pellet from Leng-Dor based on potato

Safari Mix – included snack pellet from Mafin based on potato

Cereal stripes - included snack pellet from Mafin based on wheat

Maillard reaction - A chemical reaction between amino acids and reducing sugars, that gives a brown colour and flavour.

Asparagine - A amino acid that is used in the biosynthesis of proteins.

Acrylamide threshold value - The European Commission´s regulation and acrylamide threshold value of 750 micrograms per kilo for manufacturers of chips.

Reducing sugars - Sugars where the anomeric carbon has an OH group attached that can reduce other compounds e.g. maltose and lactose

SPE – Solid Phase Extraction

LC-MS/MS - Liquid chromatography tandem mass spectrometry

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Malin Ekdahl

Introduction

Eating a balanced diet is a crucial aspect of leading a healthy life, generally involving eating three main meals and snacks in-between each meal. Snacks are often associated with food products such as chips and expanded snack products (Ciurzyńska et al., 2019). Puffed snack products are usually savoury and are the most common snacks that are consumed globally (Ciurzyńska et al., 2019). The crispy texture is one of the main characteristics that consumers find appealing in this type of product (Shieh et al., 2004). However, puffed snack pellets and chips are normally high in calories and fat, with a low content of protein, fibre and therefore perceived as unhealthy by many consumers (Ciurzyńska et al., 2019). In addition to their low nutrient content, snacks might be a source of antinutrients as for example acrylamide (FAO/WHO 2002). Acrylamide is formed in foods via series of reactions termed the Maillard reaction, which gives a characteristic flavor and brown color on foods as potatoes and bread. It is the reaction between free asparagine and reducing sugars, which are the main precursors that are responsible for the production of acrylamide (Wicklund, Østlie, Lothe., Knutsen., Bråthen., & Kita., 2006). The attention to acrylamide in food started to attract scientific research in 2002, when it was reported to have a dietary source (FAO/WHO, 2002). Research in acrylamide is particularly important as the Joint FAO/WHO Expert Committee on Food Additives (JECFA) considers its presence in food as of human health concern. Furthermore, acrylamide has been classified as human carcinogen by the European Food Safety Authority and this affirmation has reinforced the necessity for lowering the acrylamide content in food products, including potato based products such as chips (EU-Regulation No. 2017/2158).

In line with the growing health trend and consumer demand for healthier snacks, the puffed snacks and chips industry has been placed in a competitive position to deliver healthier and more diversified products. Some of the new competitive products challenging the traditional potato-based snacks are snacks based on lentils and other legumes, marketed as a healthier alternative, since they contain less fat and more protein. The growing demand for healthier snacks has led manufactures to begin experimenting with new processing techniques. The RoastR technique developed by Rosenqvists Food Technologies AB is the result of these new market and consumer demands. When cooking and expanding traditional snack pellets, heat is applied, traditionally by frying oil. However, RoastR utilizes the extraordinary thermal conductivity in salt with the aim off providing a snack pellet with an appealing crunch and crispiness without any excessive additions of fat.

The focus of the study is to evaluate if salt-roasting, as compared to deep frying, could reduce the content of acrylamide and fat without affecting the sensory qualities and texture of the final product.

Aim

The aim of the study is to evaluate product qualities as affected by two different processing techniques of snack pellets. The more conventional expansion method of deep frying in oil is compared to roasting, using salt as a heat conductor.

- Does the content of fat, water, acrylamide and salt vary depending on the processing technique?
- Does sensory qualities, *i.e.* the texture differ between the processing techniques?

Background

Expansion of snack pellets

Snack pellets are an "semi-finished product" with a high quantity of starch, to achieve the characteristic texture of puffed snacks when heat is applied. In general, snack pellets contain starchy ingredients such as cereals, potatoes or vegetable flour (Snackpellets, 2019). During extrusion of the pellets, the mixture gets sheared and gelatinized within the extruder by conditions of pressure and temperature for opening the starch granules (Kelly, 2003). The pellet requires processing to produce a finished "puffed" snack product. (Snackpellets, 2019).

The texture of the snacks is one of the main features that the consumers look for when purchasing snacks, and could be a determinantal factor for their purchasing power (Lawless & Heymann, 2010). According to Shieh, Chang and Chen (2004) there are serval different factors to consider in order to achieve the desired expansion and texture in the finished product. When expanding snack products starch, proteins and water content are important key factors to consider. Additional factors are the size, thickness and shape of the snack pellet (Shieh et al., 2004). Furthermore, does the cooking time and temperature during the processing have an impact on the achieved expansion (Shieh et al., 2004).

The expansion process occurs when rapid heat hits the remaining moisture of the pellet, when the pellets itself is exposed to a powerful heat source. The heat required to achieve expansion usually transfers through vegetable oil by frying, other methods to obtain expansion are hot air, pressure or microwaves (Shieh et al., 2004).

Salt and fat

Health aspects

There is a great interest to reduce the amount of salt and fat in food to achieve better public health (Bresson,. Flynn., Heinonen,. Hulshof., Korhonen, Lagiou, & Przyrembel, 2009). This is due to health risks associated with high intake of salt and fat in the diet such as cardiovascular diseases and some types of cancers (National Food Administration, 2019 & National Food Administration 2020a). High calorie intake met by low metabolic energy expenditure are biased towards weight gain when a high fat diet is consumed, therefore the high caloric density of high-fat diets play a primary role in weight gain (National Food Administration, 2019. & National Food Administration 2020.a). However both salt and fats are essential nutrients for humans and have been used in cooking for decades and therefore is it of great interest to develop

products as well as alternative processing techniques to produce products that are more healthy in terms of having lower content of fat and salt.

Processing aspects

Salt and fat have versatile functionalities but acts primarily as a flavour enhancers (McGee, 2004). Expansion of snack pellets occurs when they are exposed to rapid heat, traditionally through deep frying with oil. During the process of deep frying snack pellets, the fat acts as a heating medium and does not blend with the water. Due to the high temperature, the water is heated and pumped into the surrounding oil in the form of steam. (Math, Velu, Nagender & Rao, 2004). When deep frying food, the fat seals the flavour components so they stay on the inside of the crust. When the pellet expands in oil, a portion is absorbed resulting in a final product with a higher content of fat. According to the National Food Administration (2020b) flavoured fried potato chip contain around 30g fat / 100g and 1,35g salt/ 100g. Numerous international health agencies recommend that, for a woman, about a third of the daily energy intake should come from fat, this means about 70g fat per day and for a man approximately 90 g per day (Bresson et al., 2009).

Salt is not only used to provide foods with a salty flavor, but is also used to improve functional and sensory qualities of foods. According to Torrico., Nguyen, Li., Mena., Viejo., Fuentes., & Dunshea (2019) is salt a common additive within the food industry, manly for its ability to enhance flavor, improve water absorption and contribution on texture and color. Therefore, salt reduction a is major challenge for the food industry due to the great qualities and functionality of this substance. From a health perspective, the daily intake of salt should be a maximum of 6 grams (Bresson et Al., 2009). According to the National Food Administration (2020.a) the general salt intake is twice as high as the recommended intake.

Acrylamide formation

Acrylamide is a product of the Maillard reaction and is mainly formed during heat processing such as baking, deep frying and roasting of starchy foods and vegetables at temperatures above 100 degrees, (Wicklund et al., 2006). The characteristic brown colour and flavour of fried and grilled food is also a result of the Maillard reaction (Deary et al., 2002).

Potato products in the form of chips and fries are strongly associated with high levels of acrylamide since they contain the acrylamide precursors (asparagine and sugars) and are processed temperatures above 100°C. Research show that the amount of acrylamide formed varies depending on the content of sugars in the foods, cooking time and temperature. Rosen and Thompson (2018) investigated the effects of nitrogen supply during growth on the glucose and acrylamide content of tubers. The study showed that tubers vary in sugar content depending on cultivar, nitrogen supply and storage time and the authors recommends that manufacturers should choose a cultivar with low sugar content. The same conclusion was drawn by Grand, Moreira and Tichy (2004). Granda et al. (2004)´s study aimed to analyse the level of acrylamide formed during deep frying of potato chips and to evaluate means of reducing acrylamide in potato chips by using different potato cultivars. The result of the study showed a significant reduction of acrylamide formation in potato chips when decreasing cooking temperature and increasing cooking time with both frying methods, deep frying and vacuum frying (Granda et al., 2004). However, consumers have shown a greater interest in high-heat processed potato products, as both aroma and texture improves.

According to the new EU-Regulation No. 2017/2158 manufacturers of chips with higher levels than 750 micrograms per kilo are obliged to take actions to reduce the amount of acrylamide in the product. The European Commission´s regulations and threshold value are a precaution for human health since experiments on animals has shown that acrylamide can have carcinogenic effects (European Commission, 2017/2158).

Measurement of texture

Texture is defined as the sensory manifestation of the structure of food and how the structure reacts to an applied force (Meullenet, Carpenter, Lyon & Lyon, 1997). Oral texture is described as the mouthfeel perceived in the mouth by the lips, teeth, saliva, tongue and throat (Lawless, & Heymann, 2010). In some foods, the perceived texture can be a significant factor that determines the consumer´s liking or not. Both Shieh et al. (2004) and Lawless & Heymann (2010) emphasize texture as an important attribute for snack products such as chips. For these foods, a defect in texture would have a negative effect on consumer liking, soggy chips can be presented as an illustration of inferior texture. Therefore, is it important for manufactures to measure and document the products texture to maintain a consistent texture and quality (Lawless, & Heymann, 2010). Measurements of texture can be evaluated using sensory and instrumental methods.

Instrumental measurements

The texture of the product is usually assessed by measuring the required force for penetrating or breaking a dry food product. Texture profile analysis (TPA) is a common method for instrumental texture measurement (Lawless & Heymann, 2010). During a TPA the product is compressed twice using a texture analyser and the required force to penetrate the sample quantifies (Nishinari & Fang, 2018). This force gives an indication of the product's hardness and texture at the first bite (Nishinari & Fang,. 2018). Both Lawless & Heymann (2010) and Loredo & Guerrero (2011) points out that although there are different instrumental methods to measure texture, they do not consider how well this information represents human perception.

Sensory texture measurements

Sensory analysis uses the human senses as a means to either determine consumers liking and disapproval, identify similarities and differences between products or the actual and objective sensory characteristics of a product (Gustafsson, Jonsäll, Mossberg, Swahn & Öström, 2014). By using the human five senses, vision, scent, taste, sense and hearing, the perception can be quantified and documented providing a characterisation of the food (Gustafsson, et al., 2014). Sensory methods assess texture through hearing, touch, sight and mouthfeel (Lawless & Heymann, 2010).

In general, sensory analysis is divided into two categories, analytical methods and consumer methods. Analytical assessments uses a trained panel that describes the experience of sensory qualities of a product through a common vocabulary. If the panel is not sufficiently trained or have different perceptions on the meaning of the chosen vocabulary, defects may occur. For example, can the words “hardness” and “density” confuse and carry different meaning among the panellists. Consumer methods are used to analyse what consumers prefer and think about products, something that can be of great importance to predict how well products perform in the market (Gustafsson et al. 2014).

For the analytical methods, ISO standard 8586:2012 (General guidance for selection, training and monitoring for assessors, part 1 and 2) applies. The ISO standard describes the requirements that the panel members must fulfil. This is to comply with international standards and to obtain replicable results. Albinsson, Wendin, & Åström, (2013) points out that it is of great importance that each panellist have a fully functioning sense of smell and taste, a good colour vision and is properly trained. This is to ensure that the panellist can, in an objective and analytical way,

determine sensory similarities and differences between products. Consumer methods are used to measure what, how much and why consumers prefer one product over the other. In consumer testing, is it the consumers who are included in the panel. Therefore, is it important that the respondents does only consist of participants who likes and consumes the product, in order to represent the relevant target group (Albinsson et al., 2013).

Sensory analysis is useful tool for developing new products, compare already exciting products or determine the sensory qualities of a product that can then be highlighted during marketing (Gustafsson et al. 2014).

When conducting sensory analysis and using people as a measuring instrument is it important to take into consideration that they have different perceptual abilities (Meilgaard, Carr & Civille, 2006). The response of the same stimuli may vary because of the individual sensations of aromas and flavours. A further influencing factor is whether the person can translate his/hers feelings and experience into words against past experiences and memories (Gustafsson et al. 2014). Other important factors to consider when conducting sensory tests are the number of assessments, the amount of the served sample, instructions and the temperature of the sample. This to avoid any misunderstandings or defects in the assessments as well as to ensure that the samples are assessed in an uniform manner.

Triangle test

A triangle test is an analytical method to assess if there is a differences between products. When conducting the triangle test, three samples are presented to the panellists, two of which are equal and one different. The panellist's task is to assess which of the samples differs from the other two by using their senses. If the assessors do not perceive a difference between the samples, they must guess (Lawless & Haymenn 2010).

Triangle test is described in ISO standard 4120:2012 Sensory analysis – Methodology- Triangle test. This method answers the question: is there a difference between product A and B. It is important to note that the method only answers if there is a difference, and not the magnitude of difference between the samples (Albinsson et. al 2013). In a difference test, such as triangle test, the recruited panel should be trained. The recommended number of assessments for triangle testing is 20-30 (Albinsson, et al. 2013).

The results from the assessors are evaluated by filling in the "correct" answers (those cases when the panellist has been able to distinguish then deviant sample) for each sample

combination into a result scheme. The number of correct answers are summarised, and a significance level is selected. A critical value is estimated based on the selected significance level and is compared to the number of correct answers. According to Albinsson et al (2013) a significance level of 5% is most common, which means that the risk that the difference is random is less than 5%.

Lawless & Heymann (2010) mentions various factors that are important to consider when analysing the results from a difference test. One aspect to consider is that despite selection and training sessions, the panel may not be sufficiently qualified, e.g. due to illness, which can affect the sense of smell and taste which in turn can lead to defect int the result. Therefore, for participants to be qualified for the panel they should not suffer from any kind of impairment in their senses. Lawless & Heymann (2010) emphasizes the importance of coding the samples, as well as using different codes depending on the number of replicas of each test series. Coding anonymizes the samples, which reduces the ability for the assessors to figure out the assessed sample. In order for the assessors to be able to do good assessments, an appropriate work space is required (Albinsson., et al., 2013). To achieve this, there are standards that in detail describes how a sensory test room should look and be equipped, ISO 8589:2007 (General guidance for the design and test rooms). Disturbing factors to avoid are sounds form nearby premises, discussions between assessors and poor ventilation.

Material and method

Information retrieval

Study material has been collected from the databases Summon and Google Scholar as well as printed sources. The search words for literature have been based on the purpose of the study to limit the search to relevant literature.

Material

Five different snack pellets were included in the study: Flor de patata (Leng-Dor), Whole Beetroot (Nature´s Fresh), Whole Broccoli (Nature´s Fresh), Cereal stripes (Mafin) and Safari mix (Mafin), (**Table 1**). Each snack pellet was selected based on Rosenqvists Food Technologies AB previous experiences with the expansion behaviour of the snack pellet. Table 1 illustrates the main characteristics of each pellet.

Table 1. *Bulk density, water and salt content of the raw snack pellets of the study.*

Product	Based on	Bulk Density (g/L)	Water content g/100g	Salt content g/kg
Flor de patata	Potato	462	8,7	NP
Whole Beetroot	Beetroot	384	10,0	1,2
Whole Broccoli	Broccoli	396	10,1	1,0
Cereal Stripes	Wheat	468	10,3	NP
Safari Mix	Potato	336	10,1	NP

*NP = Not provided

Processing

Deep frying of snack pellets

A manual Star Wheel Fryer (SWF) filled with frying oil (*Eldorado*) was used to deep fry the snack pellets. The temperature was controlled and measured manually with a target temperature of 185 ± 5°C using a Velleman (DEM106) thermometer. Cooking time was determined by a stopwatch using the timer tool in iPhone. Timing was started as soon as the pellets were brought into the oil.

Roasting of snack pellets

Figure 1 illustrates the salt-roasting system. The temperatures used were 185°C and 170°C. The RoastR was set to a target temperature and allowed to operate for 1 h before the processing process started.

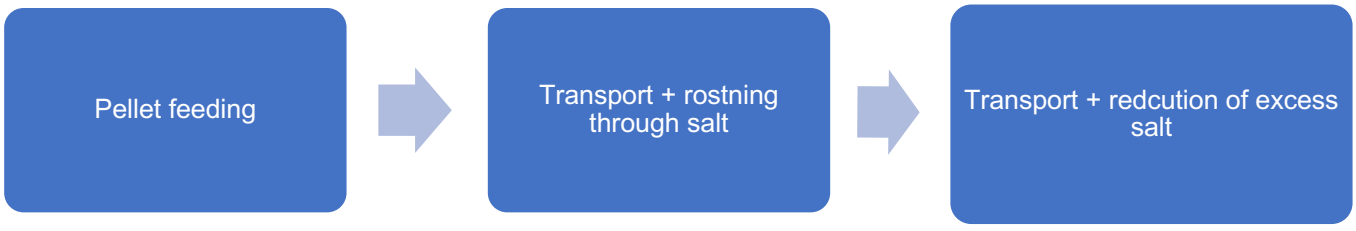

Figure 1: *Illustrating the flow chart of the processing steps for expansion of snack pellets with RoastR.*

The RoastR used in the study was of a smaller scale as compared to the one presented in **figure 2**

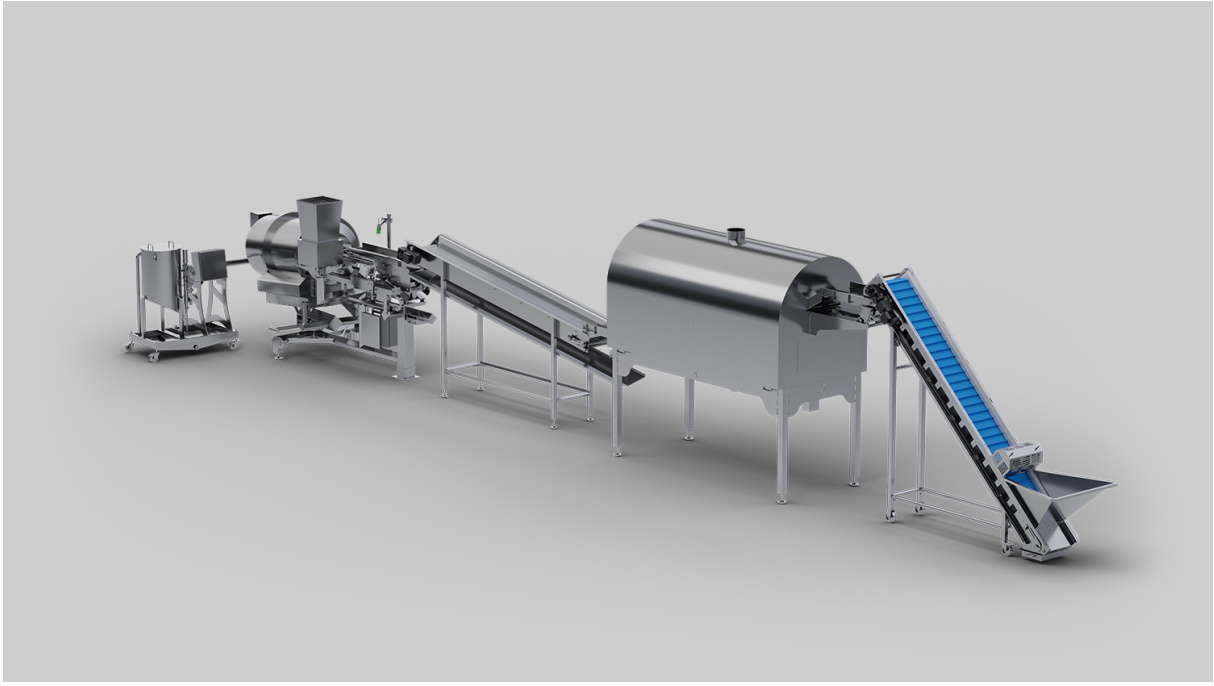

Figure 2: *Illustration of the RoastR.*

Study design

An study design was developed whose purpose is to measure the effects of several parameters on puffed snack pellets. The design included five samples of deep fried snack pellets and seven samples of salt-roasted snack pellets. Analyses of acrylamide, water, fat and salt content were conducted on each sample. An accredited laboratory, Eurofins, was used to perform analyses of fat, water and acrylamide levels of the snack pellets: raw, deep fried and roasted. A sample of 200 – 300 g was packaged and sent to Eurofins for analysis. Measurements of the salt content were performed in triplicate by the author. The definite cooking temperature and time was determined after three test rounds, the one that achieved the best expansion and texture was chosen. After a first analysis, the samples Roasted Whole Beetroot and Whole Broccoli exceeded the acrylamide threshold value of 750 µg /kg, therefore a second batch of both samples were prepared. Based on these findings the second trial was designed with a lower cooking temperature (170 °C) and longer cooking time (37s).

Table 2: Illustration of the study design

Product	Processing method	Temperature (°C)	Cooking time (s)	PQA*
Flor de patata	Raw			AC, WC, FC, SC
	Deep frying	185 ± 5	16	
	Salt-roasting a	185	30	
Whole Beetroot	Raw			AC, WC, FC, SC
	Deep frying	185 ± 5	16	
	Salt-roasting a	185	30	
	Salt-roasting b	170	37	
Whole Broccoli	Raw			AC, WC, FC, SC
	Deep frying	185 ± 5	16	
	Salt-roasting a	185	30	
	Salt-roasting b	170	37	
Cereal Stripes	Raw			AC, WC, FC, SC
	Deep frying	185 ± 5	25	
	Salt-roasting a	185	37	
Safari mix	Raw	185 ± 5	25	AC, WC, FC, SC
	Deep frying	185	37	
	Salt-roasting a			

*PQA = Product quality attributes, AC= Acrylamide content, WC = Water content, FC = Fat content, SC = Salt content.

Fat measurement

A NMKL method was used to determine the fat content. The details of the method was not disclosed by Eurofins (NMKL, NordVal International, 2020)

Water measurement

A NKML method were used to determine the water content. The details of the method was not disclosed by Eurofins (NMKL, NordVal International, 2020)

Acrylamide measurement

To determine acrylamide content, Eurofins standard analysis method based on the LC-MS/MS method were used. A homogenous sample is mixed with water and centrifuged. The sample is then filtered and purified on a Solid Phase Extraction SPE-column. Final determination is made on LC-MS/MS. At each analysis, a blank test and a control test are analysed. Additive tests are performed in each test series. Samples are analysed as a single sample with an inter-standard additive (Rosén & Hellenäs, 2002). Eurofins detailed method was not disclosed.

Salt measurement

To determine the salt content a digital Hand-held "pocket" salt meter (4250-E08) by Atago was used. The instrument uses an electric conductivity method to measure and display salt concentrations as percent (g/100g). The measurements were made in 3 replicates. 10 grams of milled sample was dissolved with 90 grams of distilled water in a beaker. Each sample was stirred until it dissolved and was allowed to sediment for approximately 5 minutes until the solids had settled to the bottom of the container. A sample of the clear liquid on top of each sample was collected using a pipette and added to the sensor of the salt meter. The result was multiplied by 10 (dilution factor). Ex. 0.90 x 10 (dilution factor) = The actual salt concentration is 9.0%. The method was implemented in accordance with the instruction manual provided by Atago.

Triangle test

Implementation

A sensory analysis in the form of a triangle test was performed. This test was chosen to identify if there was a significant difference between the samples, deep fried snack pellets and salt-roasted snack pellets. Prior to the triangle test, a questionnaire was created in the EyeQuestion software, which is a fully equipped program developed for sensory and consumer-based research (EyeQuesiton, 2020). The author formulated two main questions, Q1: difference in texture , Q2: overall difference, and finally panellists were asked to comment on the appearance, scent, flavour and texture of the sample.

All puffed snack pellets were packed in smaller plastic containers with two pellets in each and anonymized through a three-digit code, randomly selected by EyeQuestion. Each series of samples were placed in a bigger container and coded. All series were served in duplicate and

between each sample, the assessors had to rinse their pallet with a bite of an unsalted cracker and a sip of water.

The samples that have been used are based on probability selection, meaning a number of people were consciously invited, without knowing which of these would participate. Employees at Rosenqvists Food Technologies AB were invited as assessors for the sensory test, and the final panel consisted of 11 panellists, all men. The assessors were not trained or familiar with sensory assessments, therefore all assessors were given a introduction of the purpose of sensory evaluation, why it was needed and how triangle test are conducted.

The test was held at Rosenqvists Food Technologies AB premises. The rooms that were used, were not adapted to the requirements of the *International Organization for Standardization*, (ISO 8589:2007, General guidance for the design and test rooms) for sensory analyses.

In the sensory test were **110** assessments made, with **11** panellists. Each assessor tested each series two times, giving the number of **110** assessments.

Data analysis

Results of the completed triangle test were compiled in a result scheme according to Albinsson et al, (2013) to evaluate the responses (See appendix 2 for result scheme). The results were compiled and a significance level of 5% was determined. The measurements performed by Eurofins were analysed using Excel (Microsoft Office). The salt measurements were compiled and the mean, median and standard deviation were calculated using Excel (Microsoft Office). Further, descriptive statistics in the form of bar charts were created using Excel (Microsoft Office).

Ethical considerations

The study was conducted in accordance with Bryman´s (2011) four ethical principles for Swedish research*: the information's requirement*, *the consent requirement, the* confidentiality *requirement* and *the usage of information requirement*. To ensure this, all panellists were informed about the purpose of the study, its design and that it was fully voluntary to participate and that the results would only be used for the purpose of the research work (See appendix 1). The participants were also clearly informed about how the assessment would be conducted,

which according to Albinsson et al. (2013) is an important aspect to avoid misunderstandings and mistakes during the assessments.

According to ethical principles research may not cause any harm to the participant (Lawless & Heymann 2010), which in this study applied to the panel. The main risk that might have occurred to the participants were the content of acrylamide in each served sample. During the triangle test, the panellists are exposed to consume snacks with different acrylamide contents. All samples served, except two, had an acrylamide content that was well below the threshold value of 750 µg/kg. The two samples, roasted Wole Beetroot and Broccoli exceeded the limit. However, the amount served consisted of two puffed snack pellets and was not considered to expose the participants to any health risk.

Furthermore, has the document of "Good Research Practise" from the Swedish Research Council (Svenska Vetenskapsrådet) been consulted regarding further ethical considerations. The study is performed in collaboration with Rosenqvists Food Technologies AB, which led to some ethical considerations. The Swedish Research Council (Svenska Vetenskapsrådet) emphezises the interactions between the researcher and commissioning bodies. Carrying out a study on the behalf of a company increases the responsibility and motivation to achieve a useful and positive result. The ethical aspect of wanting to achieve a positive result should not affect the study. When analysing and performing tests, an objective perspective must be maintained without external influence. Since the panel for the triangle test consisted of employers form the company, a loyalty to the company could mean that assessment and management being in favour of their own products (Gustafsson, et al. 2014) in this case Rosenqvists Food Technologies AB, RoastR.

Results

The study has involved a range of analytical techniques to determine the fat, water, salt and acrylamide contents in the raw as well as the processed pellets. In addition, a sensory test was conducted using the products that were processed according to the study design.

Chemical analysis

Fat content

The fat content in Whole Beetroot, Whole Broocoli, Flor de patata, Safari Mix and Cereal stripes was measured to evaluate the effect of the two processing techniques on the fat content of the final product. **Figure 3** shows the fat content in the sample processed by deep frying at 185 ºC, and salt-roasting at and at 185 ºC and 170 ºC. The results present a distinct difference between the two processing techniques. The deep frying technique resulted in a higher fat content in the range of 20-35g/100g, compared to the salt-roasting technique the fat content of the samples was less than 5g/100g.

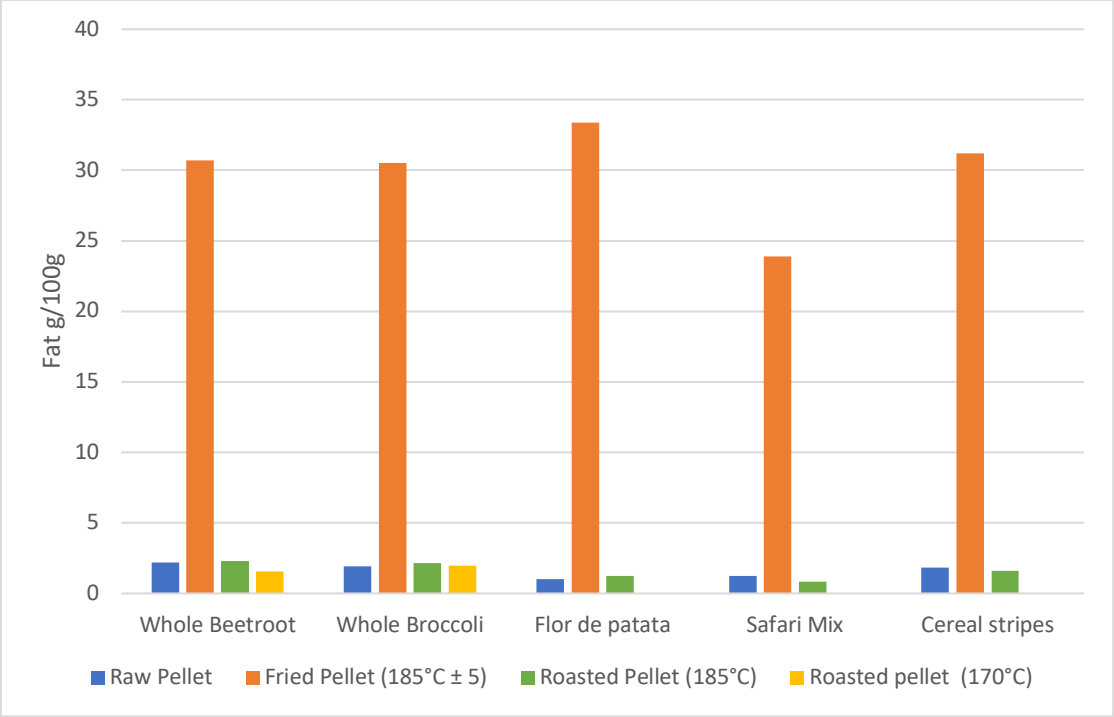

Figure 3: *Fat content of deep fried and roasted snack pellets.*

Water content

The water content in Whole Beetroot, Whole Broocoli, Flor de patata, Safari Mix and Cereal stripes was measured to test the effect of the two processing techniques on the water content of the final product. The results in **figure 4** presents a clear difference between the deep fried and roasted samples. The frying technique achieves a water reduction of more than 50%. Salt-roasting at 170 ºC results in samples with the highest water content about 5g/100g compared to roasting at 185 ºC and deep frying.

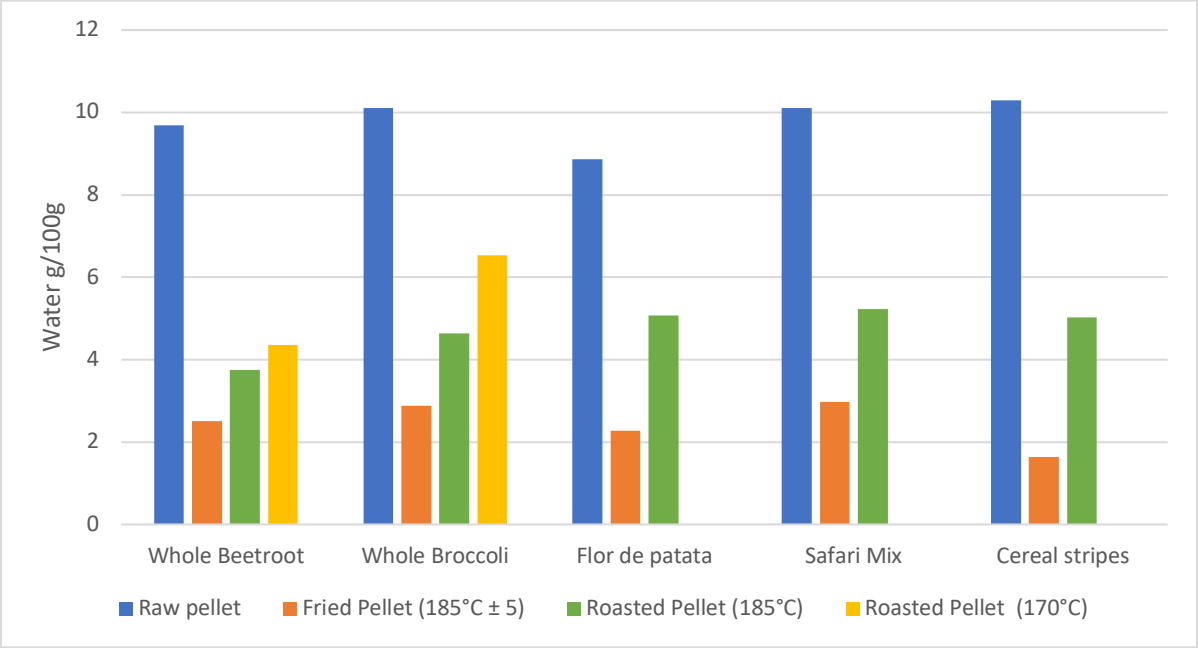

Figure 4: *Water content of deep fried and roasted snack pellets.*

Salt content

The content of salt on Whole Beetroot, Whole Broocoli, Flor de patata, Safari Mix and Cereal stripes was measured to test the effect of the two processing techniques on the salt content of the final product. The results in **figure 5** shows that the level of salt varied depending on the processing technique. The results indicate that salt-roasting results in a final product with a higher content of salt compared to deep frying. The difference between the standard deviation and mean value of salt-roasted and deep fried pellets is considerable. The samples Raw Wole Beetroot and Raw Safari mix were excluded since they had a high variation and are therefore not reliable.

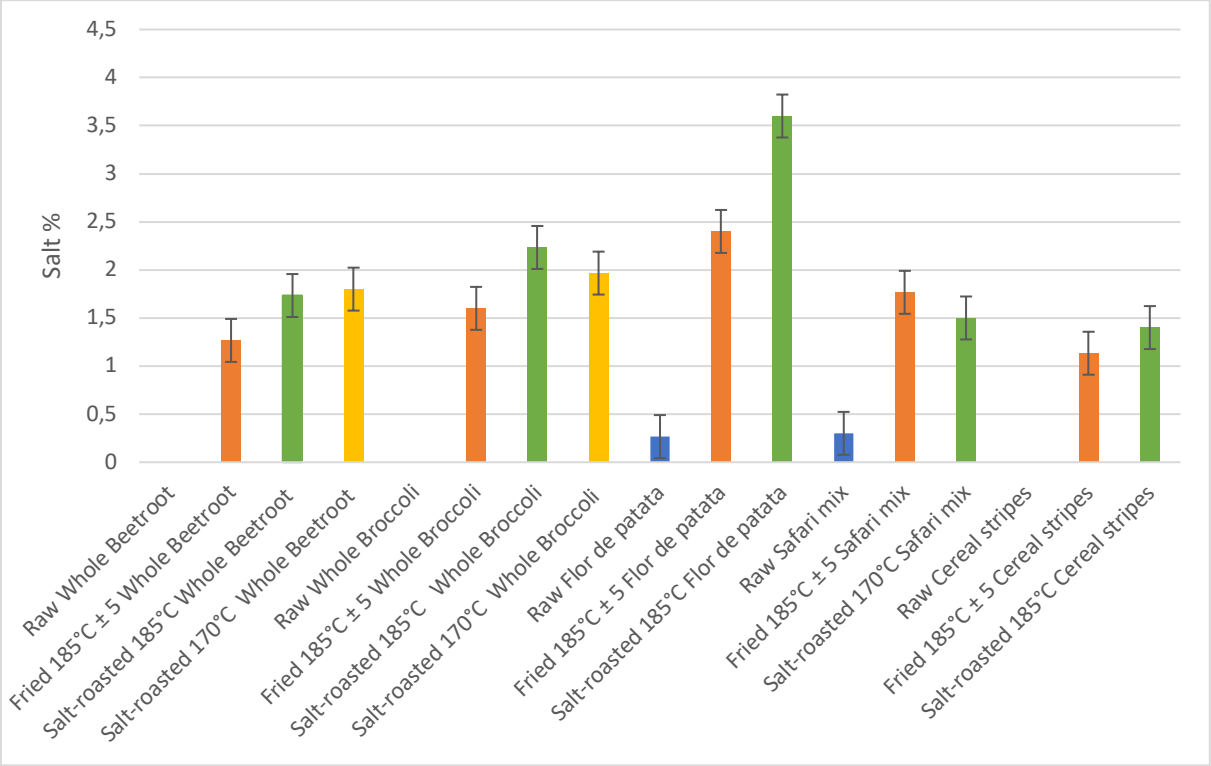

Figure 5: *Mean value and standard deviation of salt content in raw, deep fried and roasted snack pellets.*

Acrylamide content

The content of acrylamide on Whole Beetroot, Whole Broocoli, Flor de patata, Safari Mix and Cereal stripes is measured to test the effect of the two processing techniques on the acrylamide content of the final product. The acrylamide content results are presented in **figure 6**. The results show that Flor de patata, Safari Mix and Cereal stripes, has the lowest acrylamide content regardless of the processing technique. Whole Broccoli and Whole Beetroot on the other hand, exceed the threshold value of acrylamide content in chips, both fried and roasted at 185°C. The results from the second roasting session, at 170°C shows a significantly lower level of acrylamide in Whole Broccoli compared to Whole beetroot.

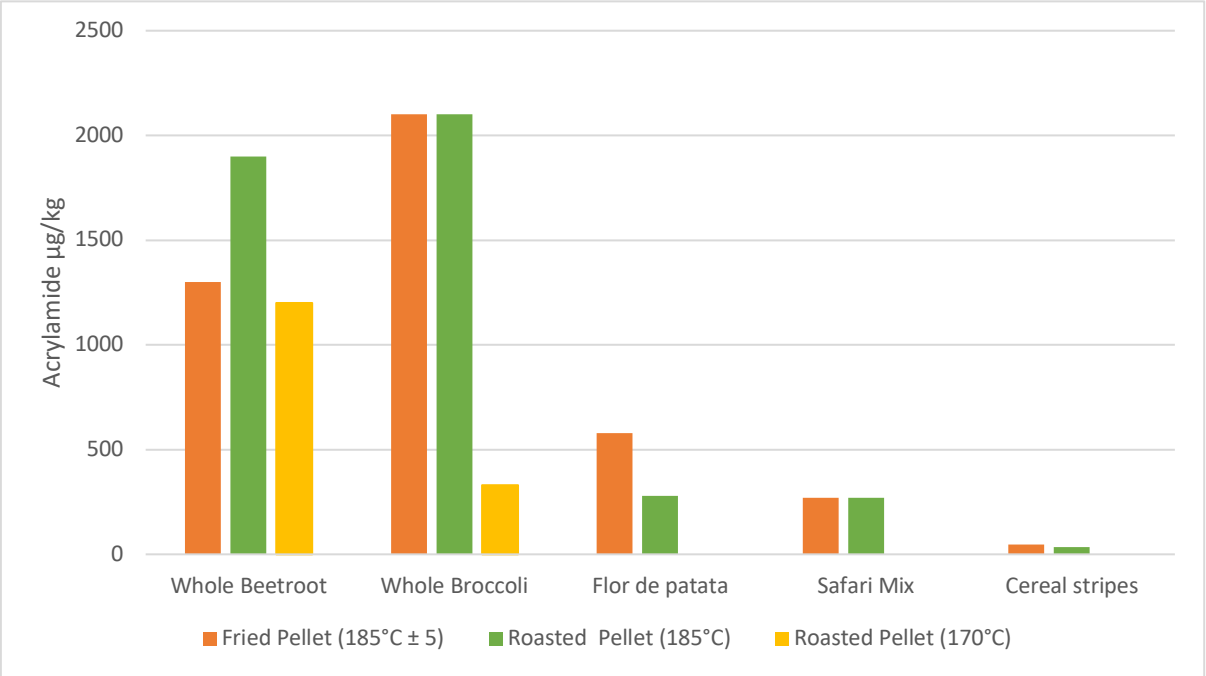

Figure 6: *Acrylamide content of deep fried and roasted snack pellets.*

Sensory analysis results

A sensory test was performed to examine if the different processing techniques affect the texture of the samples and if they were perceived by the panellists. In the study a difference test was conducted in the form of a Triangle test.

Triangle test

The results of the Triangle test showed a significant difference between the deep fried snack pellets and salt-roasted snack pellets, both textural and overall differences. **Table 3** shows that all five samples showed a difference in texture between the snack processing methods.

The triangle test included a total of 110 assessments and for each sample there were more than 12 correct answers, which is the critical value for the difference between the samples being statistically significant (Albinsson et al., 2013).

Table 3: *Illustration of the results from triangle test, number of assessments and right answers per question*

Sample:	***Assessments (n)***	***Q1 - Rights***	***Q2 - Rights***
Whole Beetroot	22	17	16
Whole Broccoli	22	21	18
Flor de patata	22	16	15
Safari mix	22	20	20
Cereal stripes	22	18	22

Qualitative comments

The results of the qualitative comments for each snack pellet and processing method are presented below. The panellists describe the perceived texture of the salt-roasted snack pellets as compact with a harder bite, compared to the deep fried pellets. The comments indicates that the snack pellets differ in size depending on the processing technique.

Table 4: *Qualitative comments on Fried Whole Beetroot*

Flavour	***Scent***	***Texture***	***Appearance***
Oily taste	Burnt oil	Less bite	Bubbly surface
Unpleasant flavour		Softer bite	Bigger in size

Table 5: *Qualitative comments on Salt-roasted Whole Beetroot*

Flavour	***Scent***	***Texture***	***Appearance***
Clear flavour		Harder	Smaller size
Better flavour		Dry	Lighter colour
		Compact	Dry surface

		Crispy	Fluffy

Table 6: *Qualitative comments on Fried Whole Broccoli*

Flavour	***Scent***	***Texture***	***Appearance***
Nice taste	A slight scent	Softer texture	More expanded
Less flavour		Oily	
Burnt taste			
Less intense flavour			

Table 7: *Qualitative comments on Salt-roasted Whole Broccoli*

Flavour	***Scent***	***Texture***	***Appearance***
Vegetable	No scent	Hard bite	More curved
More flavour		Harder crunch	Smaller in size
Clear flavour		Hard texture	Less bubbly surface
Intense flavour			Lighter colour

Table 8: *Qualitative comments on Fried Flor de patata*

Flavour	***Scent***	***Texture***	***Appearance***
Taste of oil	Has a scent	Softer ”melting”	Bigger in size
Better taste		Smooth to eat	More uneven surface
Less salty		Softer texture	Browner colour
			More expansion
			Bubbly surface

Table 9: *Qualitative comments on Salt-roasted Flor de patata*

Flavour	***Scent***	***Texture***	***Appearance***
Sweeter flavour	No scent	Harder crunch	Smaller size
More flavour		Hard texture	More colour
Clearer taste		Slightly more Dense	
Bad		Harder bite	

Table 10: *Qualitative comments on Fried Safari Mix*

Flavour	***Scent***	***Texture***	***Appearance***
Better taste	Minor scent	Nicer/Less bite	Bigger in size
Hint of oil		Soft texture	Lighter colour
		Smooth	Bubbly surface
		Crispy	Expanded
		More Fluffy	

Table 11: *Qualitative comments on Salt-roasted Safari Mix*

Flavour	***Scent***	***Texture***	***Appearance***
Less taste	No scent	Harder bite	Not expanded
Bad taste		Harder texture	Smaller size
		Much harder	Less bubbly

		Compact	Nice appearance

Table 12: *Qualitative comments on Fried Cereal stripes*

Flavour	***Scent***	***Texture***	***Appearance***
Lighter taste	Stronger scent	Less/softer bite	Lighter colour
Less flavour	Oil	Softer texture	More expanded
Less salty			Fluffy

Table 13: *Qualitative comments on Salt-roasted Cereal stripes*

Flavour	***Scent***	***Texture***	***Appearance***
Stronger flavour	No scent	Hard texture	Better looks
No oily flavour		Hard crunch	Better colour
Clear flavour		Hard bite	Smaller size
		Compact	
		More dense	

Discussion

Results

The aim of the study was to evaluate product qualities as affected by two different processing techniques of snack pellets. The more conventional expansion method of deep frying in oil was compared to roasting, using salt as a heat conductor. Products tested in this study were Flor de patata (Leng-Dor), Whole Beetroot (Nature´s Fresh), Whole Broccoli (Nature´s Fresh), Cereal stripes (Mafin) and Safari mix (Mafin). Expanded snack-products are well-known snacks that are consumed worldwide. However, these snacks are not perceived as healthy by the consumers and may also be a type of food that contain high levels of acrylamide and are high in fat and salt content (FAO/WHO 2002). Therefore, it was crucial to evaluate the effect of salt-roasting and conventional frying techniques on acrylamide content. Additionally, it was important that the novel processing technique should result in a puffed snack pellet with an appealing texture without an excessive fat content. These product attributes were critical to have in consideration since they directly affect consumers acceptability (Lawless & Heymann, 2010). The study is based on a study design that was developed to limit the number of product quality attributes to be examined and therefore the number of test trials. The product quality attributes that the study takes a closer look at are differences in texture and content of fat, water, acrylamide and salt. The results indicate that the different processing technique affects the final snack-product in several ways.

Fat and salt are essential nutrients that the human body needs. On the other hand, it is of great interest to reduce the amount of unnecessary content of salt and fats in foods, as an overconsumption of salt and fat is linked to high blood pressure, obesity and other cardiovascular diseases (National Food Administration , 2019 & 2020, a). Therefore, it was of interest to compare the content of salt and fat in puffed snack pellets depending on the processing technique. As expected, deep frying leaves a considerably higher content of fat compared to salt-roasting, since roasting uses salt as a heat conductor instead of oil (**figure 3**). This result, can be considered a positive effect in relation to pursuit of a better public health, the recommended daily fat intake, which is 70g/day for a woman and for a man 90g/day (Bresson et.al 2009). The results presented in **figure 5** indicates that salt-roasting results in a final product with a higher content of salt compared to the deep fried snack pellets. The size of

difference between the processing techniques varies, salt-roasted Flor de patata showed the biggest absorption of salt compared to the deep fried sample. However, all samples show a big difference between the standard deviation and mean value, which indicates a big variation in each samples.

The texture of the snacks is the main characteristic that attracts consumers (Shieh et .al., 2004). Shieh et al,. (2004) highlights the significance of starch, proteins and final water content in order to achieve the desired expansion and texture in the finished product. The results from **figure 4** indicates that salt-roasting does not achieve as much of a water reduction compared to the traditional processing technique, deep frying in oil. The frying technique achieves a water reduction greater than 50%. The results of Whole Broccoli and Whole Beetroot roasted in 185°C and 175 °C indicates that a higher temperature achieves a greater water loss compared to a lower temperature and longer cooking time. Water reduction is an important factor to consider during expansion, the greater water loss, the greater expansion (Shieh et.al., 2004). Therefore, water reduction is viewed as a quality challenger for the salt-roasting technique. The results from the triangle test does also highlight the effect of water reduction on the achieved texture and expansion. The panellists describe the perceived texture of the salt-roasted snack pellets as compact with a harder bite, compared to the deep frying technique.

Figure 6 presents the relationship of acrylamide content and processing technique. The results show that Flor de patata, Safari Mix and Cereal stripes, regardless of the processing technique, is by a good margin below the threshold value of 750 µg/kg. Whole Broccoli and Whole Beetroot on the other hand, exceed the acrylamide threshold value, both fried and roasted (185°C). Deary et al., (2002) explains that acrylamide formation in foods occurs when sugar and the amino acid asparagine get exposed for high temperature treatment. Research show that the amount of acrylamide formed varies depending in the content of reducing sugars and free asparagine in the foods, cooking time and temperature (Rosen and Thompson, 2018; Granda et al., 2004). This might be an explanation to comparably high levels of acrylamide in Whole broccoli and Whole Beetroot samples, however this study does not analyse the content of acrylamide precursors i.e., reducing sugars and asparagine content. Since both Roasted Whole Beetroot and Broccoli exceeded the threshold value of 750 µg /kg, a second batch of both samples were conducted. This time, with a lower temperature (170 °C) and longer cooking time (37s) instead of higher temperature (185°C) and shorter cooking time (30s). In agreement with Rosen and Thompson (2018) and Granda et al., (2004) the results showed a lower level of acrylamide in both samples. However, the reduction was significantly higher of the salt-roasted

Whole Broccoli at 170°C compared to salt-roasted Whole Beetroot at 170°C. Based on the results, salt-roasting may have a positive effect on reduction of acrylamide levels in foods. However, the achieved acrylamide reduction varies depending on the puffed snack pellet, therefore would a more comprehensive study including more trials of cooking temperatures and reducing sugars and asparagine give an indication of how big the effect of salt-roasting is.

The results from the triangle test (**Table 3**) shows that there was a significant ($p<0,005$) difference between deep fried and roasted snack pellets, which indicates a 95% certainty that there is a difference. This result was in line with the authors expectations since there was a clear difference in both texture and size between the deep fried and salt-roasted pellets. The salt-roasted pellets were significantly smaller in size, had a harder bite and compact texture compared to the deep fried pellets.

As Albinsson, et al. (2013) mentioned are there several factors to consider in order to avoid shortcomings in the results, such as distracting sounds, environment and an untrained panel. However, the difference between the number of correct answers and the critical value indicates on a reliability even though the panelists were not trained in sensory evaluation. Lawless & Heymann (2010) highlights the importance of anonymizing the samples by coding each sample with a three-digit code. By coding the samples, was it therefore possible to eliminate the ability of the assessors to figure out the assessed sample.

By evaluating the comments of the assessors, is it possible to note that there is a difference in the texture between deep fried and roasted "puffed" snack pellets. This because the overall comments about texture were very similar for each processing technique. The roasted snack-pellets were described as "less expanded", "compact" with a "hard bite" unlike the deep fried which was described as "fluffy", with a "softer bite". The panellists were also asked to comment on the samples flavour, scent and appearance. When it comes to the snack pellet´s appearance, there were a noticeable difference in size where the roasted pellets were visibly smaller compared to the fried ones, which gives a further indication of the perceived difference in texture.

The comments regarding the flavour of the snack pellets were diversified, roasted Cereal stripes, Whole Broccoli and Whole Beetroot were perceived to have a clearer and stronger taste than the deep fired samples. On the other hand, the roasted pellets based on potatoes (Flor de patata & Safari mix) were perceived as having a lesser taste and unpleasant taste.

The triangle test only answer if there are a difference between the samples, deep fried and salt-roasted snack pellets. However, by asking the panellists to comment on flavour, scent, texture and appearance, it provided an insight to the panellist´s attitude towards the various samples. However, it is not possible to draw a conclusion about their preference of one sample over the other. To ensure liking on a scientific basis, a more comprehensive study had to be conducted. It is important to point out, the significant difference does not necessarily have to be a disadvantage for the salt-roasting technique.

Method discussion

The experimental study design and the choice of the five product quality attributes were considered into the number of trials that were considered reasonable within the given time frame for the study. This means that opportunities for improvement exist and should be considered. The pellets products included in the study, were mainly developed for expansion in a traditional manner, which may have affected the products quality attributes during roasting. The temperature during the frying process was manually controlled by the author and were not able to keep consistent. This has led to a certain variation in cooking temperature and cooking time, which affects the results and its reliability. This because they are both crucial factors for achieved expansion, water reduction as well as acrylamide formation. Another factor to consider is the chosen frying temperatures and times, these were not determined after an optimum time and temperature. Factors like this makes it difficult to determine a concrete conclusion and a further development both in terms of determination of frying time and temperatures as well as pellets with properties that optimize the final product.

The measurements of acrylamide, water content and fat content were performed by an accredited company which provides a high reliability. The measurement of these parameters could have been conducted by the author, however this had entailed a need of a more comprehensive study that does not fit the given time frame.

The salt measurement was performed with a digital Salt meter. This instrument uses the electric conductivity method to measure and display salt concentrations. The samples were performed by the author, where each sample is supposed to dissolve in distilled water. Since it is difficult to demonstrate how uniformly the samples dissolve before the measurements, is there a risk that the dilution varies significantly.

Measuring the texture and mouthfeel of a food with measuring instruments and then drawing correlations to reality is complicated. Therefore, a triangle test were conducted, which is an useful method to gain a better understanding of how a food will be perceived. A triangle test is a method that answers the question, if there a difference between sample A and B. Therefore, the method does not give any indications of which one is preferred. However, by asking the panellists to comment on the samples based on their perceived texture, taste, appearance and scent, it gives indication of their attitude towards the texture.

The triangle test was planned to be performed at Högskolan Kristianstads facilities, in the laboratory that is specially designed for the purpose but had to be changed when new routines were introduced regarding Covid-19. The 3 planned replicates were also allowed to be limited

to two as it was considered that 5 samples, which generate 10 samples for the participants, were the right amount for the participants to test. This is because it was considered an appropriate number of tests for an untrained panel. To test the reliability of the triangle test, each sample was served in duplicate. This results in a certain stability, large enough to not discard the reliabilities of the study. To maintain validity during sensory evaluation, the panellists is an important factor. Within triangle test, a trained panel should be recruited (Gustafsson et al. 2014). In this case, the panel consisted of non-trained employees from Rosenqvists Food Technologies AB. However, the difference between the processing method were clear, and did not require a trained panellists to determine which sample is different from the other two. Despite an untrained panel, a significant difference between salt-roasting and deep frying pellets was determined.

Relevance to the main area of food and meal science

Maintaining and increasing food safety, food quality and public health are relevant and important factors included in food and meal science. These factors play an important role in the food industry and has a positive impact on our health. To maintain and increase a nutritional quality of food during processing is there a constant development of the products as well as the finding alternative processing techniques. The study evaluates an alternative processing technique for snack pellets in terms of achieving a lower content of fat, salt and acrylamide. The study also concerns sensory evaluation, which is a key factor for product development, as it provides indications of how the product is perceived as well as liking and acceptance by consumers.

Future studies

This study only scratches the surface regarding which parameters can be examined when comparing and evaluating expansion methods effects on different parameters. To ensure if salt-roasting reduces the formation of acrylamides, a more comprehensive study had to be conducted, a study that include more parameters such as cooking temperature and time with a bigger number of trials. Other parameters of sugar and asparagine levels would be interesting to consider in the evaluations. It would also be of relevance to examine the texture in more detail. A liking test would give a valid answer to whether the perceived texture of the roasted pellets is accepted by the consumers. Depending on the liking, it provides an indication as to

whether a further development of the product is required. A comparison between sensory measurements and Instrumental measurements of texture would also be of great interest.

Conclusion

The results indicate that salt-roasting provides a final product with lower fat content, a higher water and salt content and a lower acrylamide content as compared to conventional deep frying. Further, a significant ($p<0,005$) difference in texture between salt-roasted and deep fried snack pellets was observed. Based on the qualitative commentary of the panelists, the salt-roasted snack pellets are smaller in size and have a harder and more compact texture compared to the deep fried ones. It is important to point out that results of the study are limited and should only be considered as indications.

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Appendices

Appendix 1.

Ansvarig handledare: Malin Ekdahl

Handledare: Per Magnusson & Arwa Mustafa

Omfattning av den här studien

Du kommer nu att delta i ett triangel test som är en del av ett examensarbete om skillnader mellan rostning och fritering av snack pellets. Din uppgift som paneldeltagare är att bedöma textur samt beskriva smak, lukt, konsistens och utseende av puff-snacks. Arbetet genomförs för att mäta sensoriska skillnader mellan rostning och fritering av snack pellets.

Villkor för studien

Studien genomförs i enlighet med Brymans (2011) etiska principer för svensk forskning:

- *Informationskravet:* Forskaren måste informera sina deltagare om den studiens syfte och utformning, samt att deras deltagande är frivilligt och kan när som helst avbrytas.
- *Samtyckeskravet:* Varje deltagare har rätt att själv bestämmas över sin egen medverkan i studien.
- *Konfidentialitetskravet:* Resultaten kommer endast användas för syftet med forskningsarbetet. Ingen obehörig kommer att få ta del av dina svar.

Panelledares underskrift: _____

Paneldeltagare underskrift: _____

Appendix 2.

Sample and results chart

Product: Whole beetroot

Attribute: Q 1 = texture, Q 2= overall

Test no: 1

Date: 2020-05-13

Sample A: Fried

Codes: 745, 360, 824, 264

Sample B: Roasted

Codes: 490, 532, 518, 657

Assessor	Serving order	Code	Answer Q1	Answer Q2	Comments
1.	BBA	532, 657, 264	A	A	Less bite, different in shape & color
1.	ABA	745, 490, 360	A	A	Less bite, More color. Bubbly surface
2.	BAA	518, 745, 360	A	A	
2.	ABA	824, 657, 264	A	A	Harder texture, Smell burn oil
3.	BBA	657, 532, 824	A	A	
3.	ABB	745, 490, 518	A	B	
4.	BBA	518, 490, 745	A	A	Better texture
4.	ABA	264, 532, 824	B	B	Harder
5.	ABB	264, 657, 532	A	A	Bigger, more bubbly surface, had a smell and tasted more oily. The other samples was smaller, with a dryer surface and lighter color. The other samples tasted more
5.	ABB	360, 518, 490	A	A	Sample 360 had a more oily taste. The texture, color, surface and size was very similar between the samples.
6.	BAB	657, 264, 532	B	B	657 slighter lighter texture
6.	AAB	360, 745, 490	A	A	360 off taste unpleasant taste- nice bite

7.	ABB	824, 657, 532	A	A	824 Different looks and texture
7.	ABA	360, 490, 745	B	B	490 Lighter color
8.	BAB	657, 824, 532	A	A	Unpleasant
8.	BAA	490, 360, 745	A	A	Slightly more compact
9.	BAA	657, 264, 824	B	B	Dark color
9.	BAB	518, 745, 490	A	A	Less bite
10.	AAB	824, 264, 532	B	B	532 more dry, but clear flavor.
10.	BBA	518, 490, 360	A	A	360 more soft
11.	AAB	824, 264, 657	B	B	Smaller look, harder bite and taste better
11.	BAB	490, 360, 518	A	A	Bigger looks, no god taste, less bite

Q1 Number of "right": 17 n: 22 %: 5 Sig level: 12

Q2 Number of "right": 16 n: 22 %: 5 Sig level: 12

Sample and results chart

Product: Whole Broccoli

Test no: 2

Sample A: Fried

Sample B: Roasted

Attribute: Q 1 = texture, Q 2= overall

Date: 2020-05-13

Codes: 428, 528, 975, 674

Codes: 837, 148 , 793, 968

Assessor	Serving order	Code	Answer Q1	Answer Q2	Comments
1.	BAB	793, 528, 968	A	A	Less texture, bite More expanded & nicer taste
1.	ABA	975, 148, 428	B	B	Harder bite
2.	ABB	674, 793, 968	A	B	Taste
2.	BBA	837, 148,428	A	A	smell
3.	BAA	793, 528, 674	B	B	More curved, taste of spinach the other two samples no taste
3.	BAA	837, 975, 428	B	B	More bite and some vegetable taste. Less curved than the others.
4.	AAB	674, 528, 793	B	B	Different size and harder crunch
4.	AAB	428, 975, 148	B	B	Harder bite, morse taste
5.	BAA	968, 674, 528	B	B	Sample 968 was smaller, with a less bubbly surface, and the texture was good but with more crunch/bite. It tasted more broccoli than the others. The other samples were oily and sample 674 even had a burnt taste. They also had a smell and sample 968 didn't.
5.	BAB	148, 428, 837	A	B	428 sorter texture 148 +837 more clearer taste
6.	BBA	968, 793, 528	A	A	taste
6.	BAA	148, 975, 428	B	B	148 Harder bite lighter color
7.	BAB	968, 528, 793	A	B	793 more flavor
7.	ABA	428, 148, 975	B	B	148 straighter shape
8.	ABB	528, 968, 793	A	A	Crispy and fluffy
8.	ABA	975, 837, 428	B	B	Harder
9.	ABA	674, 793, 528	B	B	Burned taste
9.	AAB	975, 428, 837	B	B	More crunchy
10.	AAB	674, 528, 968	B	B	968 more intense flavor and harder texture

10.	ABB	975, 148, 837	A	A	975 softer texture. Less intense flavor. More fat.
11.	ABA	528, 968, 674	B	B	Smaller look, bigger blisters, better taste
11.	BBA	837, 148, 975	B	B	Smaller looks, better taste

Q1 Number of "right": 21 n: 22 %: 5 Sig level: 12

Q2 Number of "right": 18 n: 22 %: 5 Sig level: 12

Sample and results chart

Product: Flor de patata

Test no: 3

Sample A: Fried

Sample B: Roasted

Attribute: Q 1 = texture, Q 2= overall

Date: 2020-05-13

Codes: 763, 461, 843, 179

Codes: 183, 903, 268, 341

Assessor	Serving order	Code	Answer Q1	Answer Q2	Comments
1.	BAB	268, 461, 341	B	B	
1.	AAB	763, 179, 183	A	A	Softer “melting”
2.	BAA	268, 461, 843	B	A	Taste salt, small texture diff.
2.	BAB	183, 763, 903	A	B	Taste more salt
3.	AAB	763, 179, 183	B	B	More sweet taste
3.	BAB	268, 461, 341	A	A	Little bit of cheesecake taste
4.	BAA	268, 461, 843	B	B	Smaller size, harder crunch
4.	BAB	183, 763, 903	A	A	Bigger in size, taste of oil,
5.	BBA	268, 341, 461	A	A	Sample 461 tasted better, had a smell, smooth to eat. The size and color was the same as the other samples, but it had a more uneven surface.
5.	BAA	183, 763, 179	B	B	Sample 183 was smaller, with more color and taste, the texture was hard and it didn't smell. The other samples was oily, with a browner color and was bigger. The surface was more bubbly.
6.	ABA	461, 268, 843	B	B	268 Slightly more dense texture, clearer taste
6.	ABA	763, 183, 179	B	B	very similar products, 763+ 179 slight smell
7.	BBA	268, 341, 461	B	A	461 more flavor of oil
7.	BAA	183, 763, 179	A	A	All Three were alike
8.	AAB	461, 843, 268	A	A	Slightly more expanded and fluffy
8.	ABA	763, 183, 179	B	B	Slightly harder bite
9.	ABB	461, 268, 341	A	A	Hard to make decision about texture.
9.	ABB	763, 183, 903	A	A	Less salt

10.	AAB	461, 853, 268	B	B	268 more distinct and salty flavor. Texture fairly similar.
10.	BBA	183, 903, 763	A	A	183 more clear flavor. A bit harder bite.
11.	AAB	461, 843, 268	B	B	Smaller looks, harder bite, taste bad and different
11.	BBA	183, 903, 763	A	A	Bigger look, oil taste, not salt taste

Q1 Number of "right": 16 n: 22 %: 5 Sig level: 12

Q2 Number of "right": 15 n: 22 %: 5 Sig level: 12

Sample and results chart

Product: Safari mix

Attribute: Q 1 = texture, Q 2= overall

Test no: 4

Date: 2020-05-13

Sample A: Fried

Codes: 653, 409, 710, 267

Sample B: Roasted

Codes: 569, 450, 936, 351

Assessor	Serving order	Code	Answer Q1	Answer Q2	Comments
1.	BAB		A	A	Less bite
1.	ABA	653, 569, 409	B	B	Harper bite. Not expanded
2.	BAA	569, 653, 409	B	B	Hard texture, no smell
2.	ABB	710, 450, 936	A	A	Minor Smell, soft texture
3.	ABB	653, 569, 351	B	B	This item feels a bit more crunchy, more bite not so much taste.

3.	BAA	450, 710, 267	B	B	Smaller size less bubbles than other two samples
4.	AAB	710, 267, 450	B	B	Much harder
4.	BBA	569, 351, 653	A	A	Softer texture, different taste-oil?
5.	BAA	450, 710, 267	B	B	Sample 450 was very hard and smaller than the other samples.
5.	ABB	653, 569, 351	A	A	Sample 653 was bigger, with a lighter color, more bubbly surface, tasted better and had a smell. It was smooth to eat. The other samples was very hard, with a bad taste, smaller and didn't smell. The shape was better and more flat on the other samples.
6.	BBA	450, 936, 710	A	A	710 Nice bite, 450 + 936 Too hard texture
6.	AAB	653, 409, 569	B	B	569 Hard almost Too hard bite, however nice appearance
7.	BAB	450, 710, 936	A	A	Alike on everything, except 710, more harder
7.	ABA	653, 569, 409	B	B	569 Harder, no difference in flavor
8.	ABB	710, 450, 936	A	A	More expanded, slight flavor of oil
8.	BAA	569, 653, 409	B	B	Compact. Not fully expanded. Dewy, stuck in teeth.
9.	ABA	710, 450, 267	B	B	Hard texture
9.	BAB	569, 653, 351	A	A	Looks different
10.	AAB	710, 267, 450	B	B	Clear difference in texture. 450 harder.
10.	BBA	569, 351, 653	A	A	653 more fluffy.
11.	ABA	710, 450, 267	B	B	Bite and looks differ most
11.	BAB	569, 653, 351	B	B	Harder bite and looks, small diff in smell.

Q1 Number of “right”: 20 n: 22 %: 5 Sig level: 12

Q2 Number of “right”: 20 n: 22 %: 5 Sig level: 12

Sample and results chart

Product: Cereal stripes

Test no: 5

Sample A: Fried

Sample B: Roasted

Attribute: Q 1 = texture , Q 2= overall

Date: 2020-05-13

Codes: 135, 803, 328, 912

Codes: 579, 841, 786, 625

Assessor	Serving order	Code	Answer Q1	Answer Q2	Comments
1.	BAB	579, 135, 841	A	A	texture and less taste
1.	BAB	786, 803, 625	A	A	Less bite Less color & taste
2.	BAA	579, 135, 912	A	B	Taste
2.	AAB	803, 328, 786	B	B	Stronger flavor, harder texture
3.	ABB	803, 786, 625	A	A	Texture is less on this sample, and less taste than the other samples
3.	BAB	579, 135, 841	A	A	Softer bite, less taste
4.	BBA	786, 625, 803	A	A	803 smell, crunch, less taste
4.	BAA	579, 135, 912	B	B	Looks different, harder crunch
5.	BBA	579, 841, 135	A	A	Sample 135 was more expanded, bigger and had a softer bite. The other samples had a better look and color.
5.	ABA	803, 786,328	B	B	Sample 786 had a harder bite, it tasted more, had a better color and a smaller size. It didn't smell anything, whilst the other samples had a smell. The texture and taste was also better in the other samples.
6.	ABA	135, 579, 912	B	B	579 - Harder bite,
6.	ABB	803, 786, 625	A	A	803 more open (wafer type) texture
7.	BAB	786, 803, 625	B	A	803 ser annorlunda ut annars ingen stor skillnad
7.	BBA	579, 841, 135	B	A	Small difference
8.	BAB	786, 803, 625	A	A	More fluffy and expanded
8.	AAB	135, 912, 579	B	B	Compact, taste of oil
9.	BBA	786, 625, 803	B	A	Texture; hard bite Overall; color
9.	ABB	135, 579, 841	A	A	Less salt
10.	BAA	786, 803, 328	B	B	786 more dense and hard.

10.	AAB	135, 912, 579	B	B	579 Taste is more clear.
11.	AAB	135, 912, 579	B	B	Texture and looks
11.	AAB	803, 328, 786	B	B	803 and 328 smell oil/old paint, are more popped, bite is not as hard as sample 786

Q1 Number of "right": 18 n: 22 %: 5 Sig level: 12

Q2 Number of "right": 22 n: 22 %: 5 Sig level: 12