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Dairy Shop Product Development

Hybrid Drinking Yoghurt by using Bovine and Oat milk

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Foreword

This research was commissioned by the Food Application Centre of Technology (FACT) at Van Hall Larenstein in Leeuwarden. Nowadays, it is a trend to consume sustainable products as they have a lower impact on the environment. Currently, it is either consuming plant-based products or consuming dairy products. As a group, we wanted to produce a hybrid product that would still have the same characteristics as the dairy variant. That is why we, Hendrik Sijtsma, Rémon Spoelstra, Giannis Koutrios and Phonie Nguyen, developed a hybrid drinking yoghurt from bovine and oat milk on behalf of the FACT.

Summary

Dairy market plays a huge role in the food industry with the variety of high-quality products and innovation that it offers. A global transformation towards the sustainability of the plant base dietary choices though, has been noted, due to the nutritional impact that they give, promising for products which combine both animal-based and plant-based ingredients into a single food. Thus, during this project a hybrid dairy/plant-based product has been produced on behalf of the FACT while watchful on the sustainability of the product. How the product had been produced, which technological challenges had been encountered and how the product should be labelled has been researched. All of this was possible due to the FACT for offering their production location for educational project.

Faba bean powder, potato protein and oats have been used for the creation of a hybrid drink yoghurt. The faba bean resulted in a successful yoghurt visually, but it was lacking in the texture and left an unpleasant mouthfeel. The potato protein experiment was a failure. Coagulation of the protein did not fully occur, and a large amount of whey separation took place. The oat hybrid yoghurt had an increased viscosity compared to regular yoghurt and, upon processing to drink yogurt, left good impressions on taste testers due to its unique flavor profile and satisfying mouthfeel.

During storage it had been observed that the drink yoghurt forms a foam layer on top of product, during processing and storage, which hardens over time. This foam layer was caused by the circulation of the product when the heat treatment was given. The foam is undesirable because it can potentially trap air in the product, promoting microbiological growth. To prevent this from happening, experiments were preformed that led to the conclusion that a slower pump speed and processing with a vacuum atmosphere stopped the foam creation.

Also, during the storage whey separation or synereses can take place. Synereses is unwanted because it lowers client interest due to it looks unappealing. Simply swivelling or stirring the drink yoghurt would resolve this problem, however it is potentially better to add stabilizers in future productions to ensure that these symptoms do not show themselves to customers.

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1. Introduction

Food is a crucial part of people's existence all over the world. Dairy products are food items that contain many (essential) nutrients that humans need to grow. Dairy includes a wide range of products, including cheese, kefir, drinking yoghurt, milk powder, coffee creamer, etc. Because of environmental concerns people are tending to switch over from cow's milk to plant-based milk products, which are more sustainable when produced with local products.

1.1. Justification of Research

The FACT is a research wing of Van Hall Larenstein that ensures research and practice-oriented education for the students and professionals of the study Food Technology. The goal of the FACT is also to be a factory that produces short chained products made from locally produced milk which are sold locally. The FACT does also allow students to use their facilities for educational purposes. There is a research lab available for companies, research institutions and businesses for developing new products with most of the facilities made for dairy processing purposes.

1.2. Goals and Specific Objectives

Main objective: Development of a dairy, hybrid or fully plant-based product destined to be sold at cafeterias of several Universities in Leeuwarden.

Sub-questions: To accomplish the main objective, there are some specific goals/ research questions as follows.

1. What is the method of preparing drinking yoghurt?
2. Which technological challenges may occur and need to be watched closely when producing drinking yoghurt?
3. How should the labeling requirements be and how should they be designed?

1.3. Key Themes

The main objective of the Food Application Centre of Technology is to create consumer goods made from sustainable products. For example, bread paste from old bread till dairy or hybrid products from a local farm called the Dairy Campus. The goal is to sell the produced product in the cafeteria of NHL Stenden, Van Hall Larenstein and the Aeres College. With use of marketing research current trends will be taken in consideration.

2. Literature Review

To be able to start producing hybrid drinking yoghurt it's important to do literature studies onto key topics for the project. In this chapter there has been looked into nutritional values of milk and oat, the strengths and challenges of hybrid yoghurt and the additives pectin and inoculation culture. Furthermore, it has been researched how to create a label for products and the phenomenon of foam forming and its consequences.

2.1. Composition of Cow milk and Oat milk

Milk is a product that contains a lot of essential nutrients for the human body and contributes to a healthy diet. Milk contains many components that are important for dairy products. Nowadays, many people are switching to plant-based alternatives to milk for environmental or dietary reasons. There is a lot of variation in the nutritional values between these types of milk, which are displayed side by side in Table 1.

Nutrients	Oat milk	Cow milk
Macro Nutrients	(g/100g)	
Fat	1.45	3.54
Protein	0,46	3,26
Carbs	3,67	4,9
Vitamins	(μg/100g)	
A	-	29,2
C	-	202,3
E	513,7	89,1
Minerals	(mg/100g)	
P	28,9	92,4
Na	39,5	38,1
Mg	4,2	10,0
K	29,6	161,5

Table 1. Nutritional composition of Cow milk and Oat milk (Walther B, 2022)

2.2. Composition of Oat

Oats are already widely used in the industry for producing plant-based milk. All the nutrients in oat milk come from oats, which are rich in various bioactive substances and nutrients. Oats are also a healthy source of functional proteins, lipids, vitamins, dietary fibers, minerals, flavonoids, tocopherols, avenanthramides, and starches. (Xinping L., 2022) (Yu Y., 2022)

Oat milk contains a water-soluble dietary fiber, β-Glucan (0.5g/100g oat milk). β-Glucan plays a significant role in lowering cholesterol, blood lipids, and blood sugar, mainly because it can delay gastric emptying and reduce food intake by increasing the viscosity of food. (Singh R., 2013) (A.S., 2002)

Although oat milk is rich in a variety of nutrients and dietary fiber, it lacks certain amino acids, calcium, and vitamin A compared with milk, which makes it unsuitable for children during their growth and development. Therefore, dairy products for children under 5 years old cannot be completely replaced with oat milk. (Sethi S., 2016)

Furthermore, oat milk is richer in unsaturated fatty acids and contains a variety of bioactive components and dietary fibers, which prevent diseases. Therefore, consuming oat milk also has health benefits for the human body.

2.3. Oat based Yoghurt

Oat milk is attracting a lot of attention among dairy alternatives. This is partly due to the composition of oats. Oats contain a lot of starch, which can be broken down into mono- and disaccharides with the help of enzymes. As a result, the product has a sweet taste without added sugars. Furthermore, oat milk also contains dietary fibers that ensure good nutrient absorption in the intestines. Oat milk also has the property of being naturally whitish in color, making it visually similar to cow's milk. Oat milk that has not undergone enzyme treatment has a completely different composition than milk; for example, its sugar content is lower, and its fat content is also lower. This affects the fact that yoghurt made from 100% oat milk does not resemble traditional yoghurt, primarily because the taste differs.

2.4. Hybrid Yoghurt

Regarding to some articles, more than 42% of global consumers are flexitarians, or simply looking for more plant-based dairy products. Furthermore, 21% of consumers responded to the Food and Health survey of International Food Information Councils that they start following a plant-based diet to protect the environment. For that reason, more hybrid milk products, which is a combination of cow milk and plant-based materials such as oats or nuts, appear to approach their potential customers. (Gerdes, 2023)

It is undeniable that there are various reasons of consuming hybrid plant-based dairy products. First of all, as protein intake is still considered the most, hybrid products are encouraging to have much plentiful amount of protein content than the regular ones. Particularly, each serving of plant-based dairy yoghurt is enriched to 10 grams, whereas there are only 3,5 gram in yoghurt made from whole milk. Apart from that, plant-based material such as oats contain a lot of nutrients, which have already been mentioned in the previous part. Secondly, eating hybrid dairy products can reduce sugar consuming, and subsequently the daily calories. It is analyzed that products of half milk – half oats contain 6 grams of sugar, which is more than half lower than regular milk. Therefore, Nutri-score is accordingly improved from rating D to A. Last but not least, the combination of cow milk and animal-free material can create a unique taste, so that it is supposed to bring customers a promised experience. As a result, the group of potential customers can be extended. (Gerdes, 2023)

On contrast, there are also some of drawbacks in parallel. Consumer perceptions and acceptance of new ingredients can be mentioned in this case. Since traditional dairy products have belonged with consumers from centuries to centuries, it is a challenge to hybrid products that need to be suitable for a large group of consumers' taste. Furthermore, the association requires advanced technologies to maintain the desired taste, texture and nutritional properties.

2.5. Labelling Requirements and Regulation

Each food product has a label that includes, among other things, the ingredients used and allergens. This is very important because it gives the customer an idea of what they are buying. Within Europe, agreements have been made on what should be on a label, these agreements and regulations are mentioned in the European Regulation (EU) No. 1169/2011. The regulation contains a basic list of indications for food products. The basic list is shown below.

1. Product name
2. Ingredients
3. Allergen labeling
4. Quantitative ingredient declaration
5. Net quantity
6. Best-before date
7. Storage instructions/conditions
8. Brand name and address of the production location
9. Country of origin
10. Instruction of usage
11. Percentage of alcohol for beverages containing more than 1.2% alcohol
12. Nutritional value

2.6. Pectin

Pectin is a soluble fiber (polysaccharide) found in fruits. It serves many purposes in dairy, controlling syneresis phenomenon. In drinking yoghurt production, high methoxy (HM) pectin and low methoxy amidated (LMA) pectin, extracted from citrus fruits or apple and a small percentage of dextrose, are supposed to control viscosity and mouthfeel. In addition, pectin can protect milk proteins during heat treatment, so that a stable product with perfect mouthfeel is desired. (DSM, 2020)

In the experiment, HM pectin (58-60%) is used with 0,6% of total amount of produced set yoghurt.

2.7. Culture

Inoculation culture is required for the production of the yoghurt. The bacteria will convert lactose of the milk to lactic acid which will decrease the pH value and cause the milk protein casein to coagulate, forming the structure of the yoghurt.

For the production in this project the “DELVO YOG FVV-120 series” culture has been used. This choice has been made by going over the available cultures at the university’s application data sheets and selecting one that would fit the production parameters. The selected culture is commonly used for high quality and consistently stirred, drinkable and concentrated yoghurts. The culture is a mixture of *Streptococcus thermophilus* C *Lactobacillus delbrueckii subsp. Bulgaricus*. The culture is stored frozen and should be used by quickly taking the required amount before it starts to thaw. The fermenting temperature lies between 37 °C and 43 °C. (DSM Food Specialties B.V. , 2021)

2.8. Foam Forming

Milk has the property of foaming, which usually does not pose a problem, but during the production of drinking yoghurt, pectin is added, causing the foam to become stiff and hard, resulting in a foam layer on top of the product. The foaming of milk occurs because the proteins surround the air bubbles during heating. The air bubbles can form due to the steam wall but can also result from air entrainment in the machine during certain processes. Foam also has the disadvantage of trapping air in/on the product, which can promote microbial growth. Therefore, it is important to minimize the amount of foam in your product.

3. Method and Materials

Here will be described what methods have been applied to produce hybrid drink yoghurt and what materials were of importance to the process.

The primary ingredient in this project is milk. Additional materials of plant-based milk alternatives like fava bean powder, potato powder and oat milk, are included. To ensure the final product remains uncontaminated, all ingredients are processed under stringent hygienic conditions at the FACT (Food Application Centre for Technology)

3.1. Milk Collection and Processing

Milk material is collected from Dairy Campus on a weekly basis, with the amount of approximately 25kg each batch. Then it is transferred to the FACT and stored at 5-7oC in the storage room.

3.2. Drink Yoghurt Production Process

Drink yoghurt is a product made from dairy-based yoghurt. The production takes 2 days to make in the FACT, in which the first day set yoghurt is made and the second day where the yoghurt is processed to drink yoghurt.

On the first day the milk used for production can be standardized to get the desired fat percentage. In this project it has been decided to use the whole milk that is available without standardization to have a milder processed product. This means that the milk used for the drinking yoghurt skips the separation part of the process.

The milk will be heated up to a temperature of 45°C using the BG10 (Batch vacuum processing system) to liquify the milkfat. After reaching the temperature the milk will be homogenized at 200 atm to make the milk stable, reducing chances of syneresis and creaming of the end product.

After homogenization the milk will be pasteurized at 85°C for 5 minutes, to make a safe to consume and store product, which after will be cooled down to 45°C for the fermentation step.

For the fermentation to yoghurt, the milk will be put into a machine-controlled water bath (Warm Bath Fermenter) that keeps track of the temperature and pH of the product. “DELVO YOG FVV-120 series” culture will be added to the milk by dissolving it in a small portion of the milk before adding it back to the whole batch. The milk will be stirred for a few minutes to make sure the culture is fully spread out over the milk and the fermentation process can begin. When the product reaches a pH of 4.6 the water bath will cool down to approximately 15°C after which it can be stored in the cooling cell or be used for production of drink yoghurt.

On the second day the yoghurt will be processed to drinking yoghurt. To start the yoghurt will be mixed with sugar and HM pectin. This will increase the viscosity and stability of the drink yoghurt. Firstly, a small amount of the yoghurt will be heated up to have an easier dissolving of the pectin and some of the sugar. After all of it is dissolved it will be added back to the whole batch and will be mixed for ca. 15 minutes with the ultra-turrax with the remaining sugar.

After mixing the product will be homogenized at 200 atm again to restructure the yoghurt to a more drinkable product. Following this the yoghurt will be pasteurized at 73°C for 20 seconds to make sure any potential cross contamination risks during processing have been eliminated. The product will be cooled down to ca. 12°C and will be packed in cups and stored in the cooling cell. (E.J. Oosterloo, 2015)

3.3. Flow Diagram

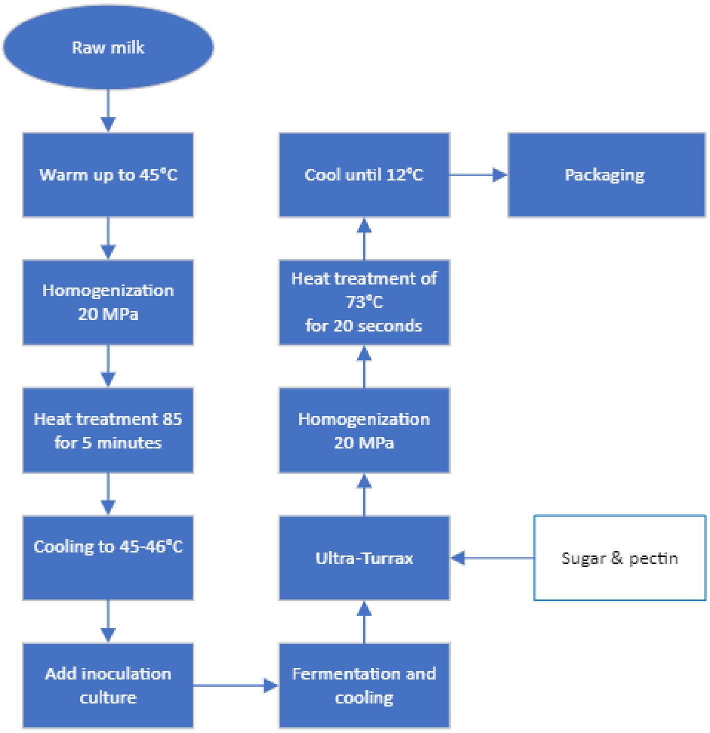

Figure 1. Flowchart of drink yoghurt production

The process flowchart is shown in Figure 1. (Flowchart of drink yoghurt production) which follow the steps described in chapter 3.2.

3.4. Machines and Equipment

3.4.1. BG10 (Batch Vacuum Processing System)

During the production process the pasteurization and heating steps are done using the BG10. The BG10 contains the following parts: Homogenizer, Lobe Pump, Vacuum Pump, Ventilation, 10-litre drum with agitator, Hoppers, Sensors and a Control panel.

Figure 1. BG10

The BG10's valves are installed between the pipes and must be manually operated. Some of the pipes are parts of the CIP system and must be removed before production can begin.

The hoppers are used to add ingredients to the main drum of the BG10. This is done with use of a vacuum pump that uses a pressure of ca. 600 mbar. The main drum has a capacity of 10 liters with a minimum of 4 liters. Attached to the drum is an agitator to stir the contents of the drum at approximately 55 rpm. The upper side of the drum has a looking glass installed to inspect the contents during production. On the drum are pressure and temperature sensors installed to regulate the process steps. The drum is enveloped by a sheath that can be used to heat up the drum and its contents using steam up to 135°C. To circulate the contents through the BG10 a lobe pump is being used. (Quartel, 2018-2019)

3.4.2. MPV106-FE Warm Bath Fermenter

The MPV106-FE warm bath fermenter is a system consisting of two water baths with space for four buckets with a capacity of ca. 5.5 liters each. The contents of the buckets can be stirred with the mixers installed above the baths. The bath can be heated by multiple heating elements set on the control panel. A water pump is installed to circulate the body of water to provide an even temperature distribution. pH measurement can be done to regulate the fermentation progress, and upon reaching the desirable target the bath temperature can be set to automatically start cooling the products down. (OMVE Lab C Pilot Equipment, 2017)

Figure 2. MPV10c-FE

3.4.3. Pilot-scale High Pressure Homogenizer

Two-stage homogenizers use two valves in sequence. The first stage applies high pressure to create the initial size reduction, and the second stage reduces the size of remaining larger particles and helps in the de-aeration process. The second stage helps to break down aggregates and improve the stability of the emulsion.

The unhomogenized product enters the valve seat from the pump cylinder at a relatively low velocity but at a high pressure. For example, the velocity may be about 3.05 to 6.10 m per second. The pressure will be (200 bar). This pressure is generated by the positive-displacement pump and by the restriction to flow caused by the valve being forced against the seat by an actuating force. The positive-displacement pump provides a relatively constant rate of flow and, therefore, will generate the required pressures as the flow area between the valve and seat is increased or decreased. The liquid flows between the valve and seat at high velocity. As the velocity increases, the pressure decreases producing an instantaneous pressure drop. The liquid then impinges on the wear ring (impact ring) and is finally discharged as homogenized product. (FLOW, n.d.)

3.4.4. Ultra-turrax/ IKA Ultra Turrax T25 Digital Homogenizer

When it comes to professional particle reduction, Ultra Turrax is used. During the preparation of drinking yoghurt, incorporating pectin, ensures a smooth, consistent, and stable final product. Ultra Turrax is the responsible device for stirring this pectin, providing precise speed control and allowing easy monitoring of operational parameters.

With a wide range of speed to ensure the pectin is well incorporated, Ultra Turrax starts at a lower speed and gradually increases the speed to a higher range for a more thorough homogenization. It has a user-friendly interface with straightforward controls, and it has been designed for robust performance and long-term use, equipped with overload protection and other safety mechanisms.

Figure 3. Ultra Turrax

3.5. Chemical Composition Analysis

Chemical measurements are fundamental in experiments and research studies when developing a product from the raw materials to the intermediate products and the final products, to ensure safety and quality in manufacturing processes as well as reliable and reproducible results. Each parameter requires specific analytical techniques, and careful sample preparation and handling in order to achieve the ultimate objectives. Tools including a lactoscope and pH sensors from the fermentation station were applied to analyze and ensure the consistency of the incoming milk and measure the acidity of the intermediate yoghurt.

Lactoscope Analysis: Lactoscope (Model FT-A, PERKINELMER) is employed to determine various parameters of milk such as fat content, protein levels, lactose content, and other solids.

A 50ml raw milk sample is being collected for every different batch and it is placed vial into the sample holder after calibrating the lactoscope device, according to the manufacturer's instructions, ensuring that everything is clean and free from any residues that might affect the readings. Later on, the device calculates the concentration of milk's components by measuring the light absorption and the scattering properties of them.

pH Analysis: Continuous pH measurements were performed during the yoghurt fermentation process until the desired end pH was reached. Acidification of milk by bacterial cultures is thus a key mechanism that gives the characteristic texture, flavor, and shelf life of yoghurt. In general, the production of lactic acid lowers the pH of the milk from about 6.5 to around 4.6. This drop in pH causes the milk proteins (casein) to coagulate and precipitate giving the milk a yoghurt-like viscous texture. (Anne G. De Brabandere *, d 1 February 1999)

The pH meter is calibrated using standard buffer solutions to ensure accuracy. pH sensors are installed as part of a monitoring probe inserted into the vessel. Proper installation ensures accurate and consistent measurements. The automated control system adjusts the pH by adding acids (e.g., lactic acid) or bases as needed to maintain the optimal pH range for the microbial culture.

3.6. HACCP Analysis

The HACCP system offers a structured approach to the control of hazards in food processing and properly applied, identifies areas of concern and appropriate control measures before product failure is experienced. In particular, the system identifies seven aspects of production that merit constant attention and these aspects are enshrined in seven principles:

I. ***Conduct a Hazard Analysis:*** Any potential hazards associated with yoghurt production from the collection of raw materials through to manufacture, storage and distribution including biological (cross contamination while mixing), physical (foreign materials: metal, glass) and chemical (such as residues, mycotoxins, and antibiotics), must be identified. An assessment made of: the likelihood that a given hazard will arise; and the preventative measures that are necessary to reduce any inherent risks.

II. ***Establish Critical Control Points (CCPs):*** Identify the precise points that can be controlled, for instance in the Pasteurization/ Cooling/ Fermentation/ Storage process steps, in order to eliminate a hazard or minimise the risk of occurrence to acceptable levels.

III. ***Establish critical limits:*** Set of targets which must be achieved in order to find the allowable range to claim control over a CCP/CP, e.g. total colony counts on product contact surfaces (CCP) or the viscosity of stirred yoghurt.

IV. ***Establish a monitoring system:*** Record the particular facets of production that are under control at each critical control point.

V. ***Implement an agreed program of corrective action:*** If the monitoring indicates that a CCP/CP is not under control, these actions should ensure the product is safe and control the hazard before the product reaches the consumer.

VI. ***Verification:*** Systematically checking that the HACCP plan is implemented correctly and that it effectively controls the identified hazards.

VII. ***Record-Keeping and Documentation Procedures:*** A system of documentation must be in place that records accurately the details of all operations, e.g. times/temperatures and microbiological parameters.

VIII. 4 results (Hoolasi, 2005)

3.7. HACCP Plan

HACCP (Hazard Analysis and Critical Control Points) plan is designed for identifying potential hazards and establishing critical control points to ensure the safety and quality of the yoghurt. The hybrid yoghurt ingredients include plant-based material, cow milk, yoghurt cultures, sweeteners, and pectin. The product is packaged in plastic containers, ensuring a shelf life of 14-21 days under refrigeration temperature.

The production process goes from receiving raw materials, pasteurizing, homogenizing, inoculating with cultures, fermenting, to adding pectin and sweeteners, packaging, finally storing and the product. Each step has potential hazards that are necessarily controlled by specific measures. In the receiving stage, pathogens, chemical residues, and physical foreign objects, considered spoiling the raw materials, are prevented by supplier verification and testing for contaminants. The critical control points (CCPs) are responsible for verifying supplier quality assurance and inspection results. During pasteurization, the critical limits maintain a temperature of 85°C for 30 minutes so as to kill pathogens, and monitoring is essential to ensure compliance. Then, cooling the pasteurized mixture to 45-46°C within 30 minutes can be applied to prevent pathogen growth, with continuous monitoring and recording. Furthermore, inoculating cultures requires using sterile cultures and sanitized equipment, verifying culture quality, and handling them properly. For fermentation, which involves maintaining the mixture at 43°C for 6-8 hours, requires temperature and time monitoring. Then set yoghurt as the product of fermentation is cooled to 4°C or lower within 2 hours, with monitoring to prevent microbial spoilage.

In the next step, set yoghurt will be added pectin and sweetening, involve using quality-approved ingredients and maintaining equipment sanitation, with verification of ingredient quality as a CCP. During packaging, the use of sanitized containers and a hygienic environment is critical, with monitoring of the packaging area and container inspection. Finally, storage through temperature regulation is needed, with monitoring during storage and transport. Potential risks, which can be pathogen growth, contamination, and foreign objects are mitigated by temperature control and proper storage conditions, with CCPs involving temperature monitoring logs.

Monitoring procedures include inspecting and testing raw materials upon receipt, regularly checking storage temperatures, verifying cleanliness of equipment during mixing, and continuously monitoring pasteurization and cooling temperatures and times. Corrective actions involve rejecting contaminated materials, adjusting storage conditions, re-cleaning equipment, re-pasteurizing or discarding under-processed batches, and handling compromised batches appropriately. Verification procedures involve conducting regular audits of the HACCP plan, reviewing monitoring records, and performing periodic testing of finished products. Record-keeping includes maintaining logs of supplier verifications, inspections, sanitation procedures, and corrective actions.

4. Results

During this project it has been attempted to make a hybrid drink yoghurt from faba bean powder, potato starch and oat milk. In this chapter these products will be evaluated and any challenges encountered during the process and how those were solved are also addressed.

4.1. Product Evaluation

4.1.1. Faba bean powder and Cow milk

The hybrid drinking yoghurt created from faba bean powder and cow milk presents a distinctive product with a moderate viscosity, less thick than traditional set yoghurt but still maintaining a pleasant consistency for a drinking yoghurt. Additionally, the color is much lighter than others when putting on scale. The taste is prominently influenced by the faba bean powder, giving it a noticeable beany flavor that stands out due to the quantity of powder incorporated into the milk. While the addition of pectin and sugar is effective in balancing sweetness and enhancing the viscosity, the faba bean powder introduces a grainy texture to the yoghurt. This results in a texture that is less smooth compared to other commercially available yoghurt products, leading to a gritty sensation in the throat after consumption. The rough texture, attributed to the faba bean powder, significantly detracts from the overall sensory experience, causing discomfort and an undesirable mouthfeel for consumers. This texture issue was a critical factor in the decision not to approve the product for manufacturing and market release. The gritty sensation is not aligned with the smooth and creamy texture expected by yoghurt consumers, thereby affecting the product's market viability.

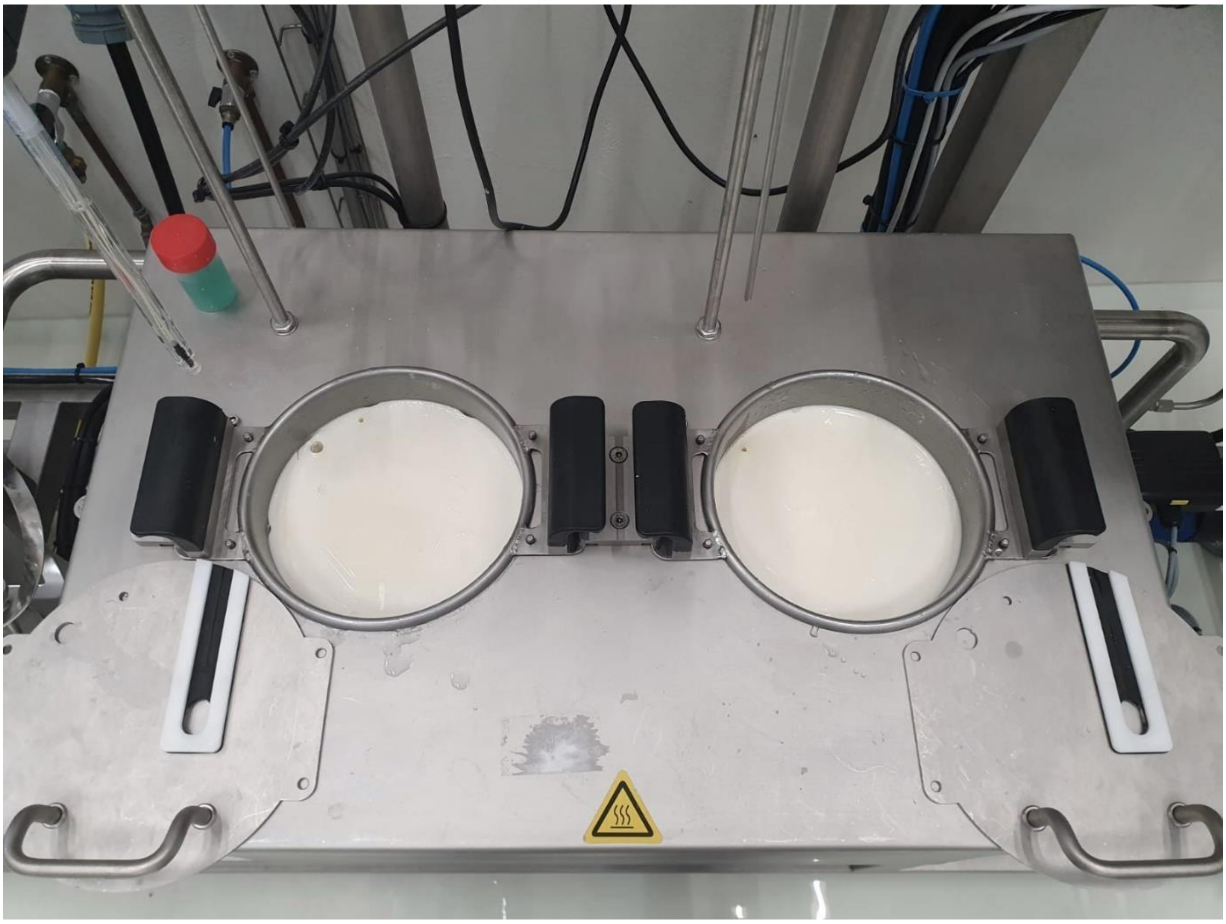

Figure 4. Visual result of Faba bean hybrid yoghurt

To address these issues and improve the product's marketability, a redesign and modification of the ingredient composition are essential. One potential solution is to reduce the amount of faba bean powder used, which may help mitigate the sandy texture and achieve a smoother consistency. Additionally, exploring alternative processing methods or incorporating other texturizing agents could further enhance the mouthfeel. By carefully adjusting the formulation, it is possible to retain the unique nutritional benefits and flavor profile of the faba bean while creating a more palatable and consumer-friendly yoghurt product. Such improvements could ultimately lead to a successful product launch and acceptance in the market.

4.1.2. Potato starch and Cow milk

The combination of potato starch and cow milk did not meet our initial expectations, failing to achieve the desired outcome from the stage of producing set yoghurt. Despite undergoing fermentation, the process resulted in a yoghurt with a significantly low pH level and a yield that fell short of anticipated quantities. Figure below revealed that the yoghurt separated during production, with a noticeable milk slight coagulation sinking of product to the bottom while the whey flowed on top. This separation severely impacted the overall yield of the set yoghurt, rendering the amount produced insufficient for commercial viability. Several factors contributed to this outcome. Firstly, the presence of potato starch likely interfered with the fermentation process, affecting the culture's ability to adequately acidify the milk. This interference not only lowered the pH below the desired range but also hindered the formation of a cohesive yoghurt structure. Secondly, the instability introduced by the starch may have prevented proper curd formation, leading to the observed separation of whey and curds. As a result, the project necessitates a revaluation of ingredient proportions and processing techniques to overcome these challenges and achieve the intended outcome of producing a stable and commercially viable set yoghurt.

Figure 5. Visual result of hybrid potato yogurt

4.1.3. Oat and Cow milk

The hybrid drinking yoghurt, which combines soaked oats and cow milk, represents a cutting-edge innovation aimed at leveraging the nutritional advantages of oats, as well as creating a unique taste of hybrid dairy product. This experimental approach not only seeks to broaden the range of yoghurt options available to consumers but also aims to address evolving dietary preferences and nutritional needs. Throughout the intricate process of making this yoghurt, several significant observations and characteristics have emerged, shaping its distinctive identity and influencing its overall appeal in the market.

During the fermentation phase, a notable discovery was the slightly lower pH level observed in the oat-cow milk yoghurt compared to traditional yoghurt. This strong decreasing in acidity can be attributed to the natural properties of oats, which introduce a subtle acidity due to their composition and interaction with the yoghurt cultures during fermentation. Despite this mild acidity, the yoghurt exhibited commendable stability with minimal whey separation, indicating robust curd formation and effective utilization of milk solids. This stability is crucial for ensuring a smooth and cohesive texture in the final product, enhancing its sensory appeal.

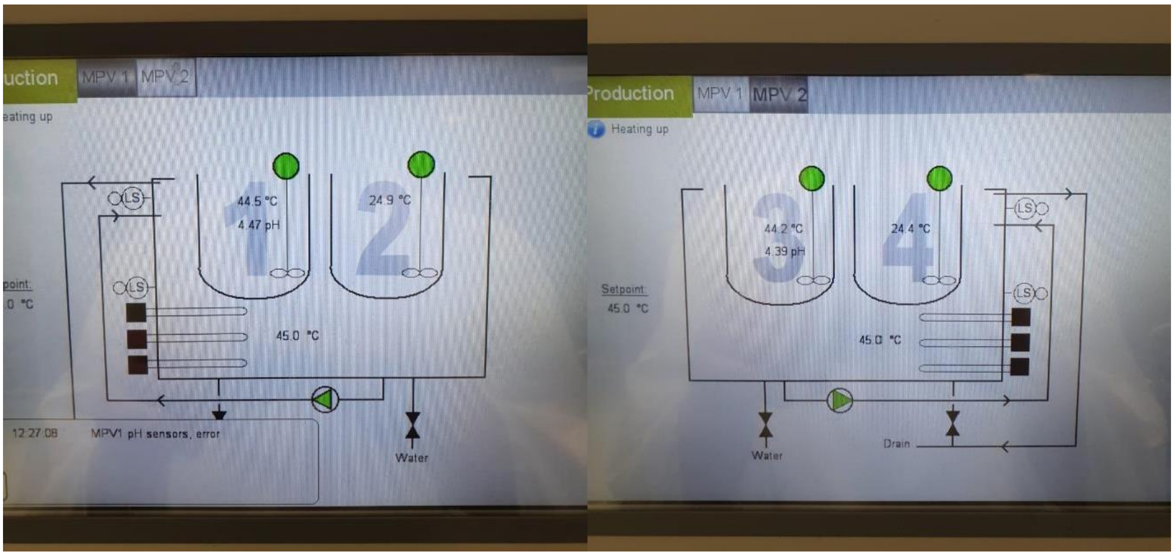

Figure c. Control panel fermenter with pH and temperature measurements

One of the standout characteristics of this hybrid yoghurt is its significantly elevated viscosity in comparison to yoghurt made solely from animal-based milk. This viscosity not only impacts the yoghurt's texture but is also visually striking, with the yoghurt's surface displaying a dense and cohesive appearance almost similar to dried clay, which can be seen on the below picture. This substantial texture is achieved through mixing techniques during the incorporation of sweeteners and pectin, ensuring optimal mouthfeel and uniform distribution of flavors and additives throughout the yoghurt.

Figure 7. Visual result of hybrid oat yogurt

In sensory evaluations, the hybrid drinking yoghurt consistently received positive feedback from testers, who often preferred its flavor and texture over traditional yoghurt variants. Despite its dense set yoghurt texture, the viscosity of drinking yoghurt is closely resembling to regular yoghurt. As a result, the hybrid's appeal lies in its unique flavor profile and satisfying mouthfeel. Interestingly, despite containing an equal amount of sugar, approximately 8% of the total yoghurt content, the hybrid yoghurt exhibited a slightly less sweet taste compared to traditional one. This suggests complex interactions between oats, milk, sugars, and cultures during fermentation, underscoring the intricate flavor development process inherent to yoghurt production. Visually, the oat-cow milk yoghurt presents with a creamy hue that sets it apart from the typically brighter appearance of traditional yoghurt. This visual distinction may be attributed to natural colorants in oats or chemical transformations such as Maillard reactions, which occur during heating and contribute to color development in dairy products.

Detailed analysis of both raw materials and the final product revealed unexpected trends, particularly a decrease in fat and protein content relative to conventional yoghurt production. Typically, yoghurt production results in increased fat and protein due to the concentration of milk solids during fermentation. However, the incorporation of oats introduces a unique dynamic, as oats contribute more carbohydrates and fiber than protein to the yoghurt mixture. This dilution effect on protein density highlights a nutritional trade-off, where texture enhancement and fiber enrichment must be balanced against protein content, particularly for consumers prioritizing protein intake. Furthermore, the addition of sugar (sucrose) to achieve desired sweetness levels significantly increased the lactose content of the hybrid yoghurt. This finding underscores the importance of considering nutritional implications in product formulation, especially for consumers managing dietary restrictions related to lactose intolerance.

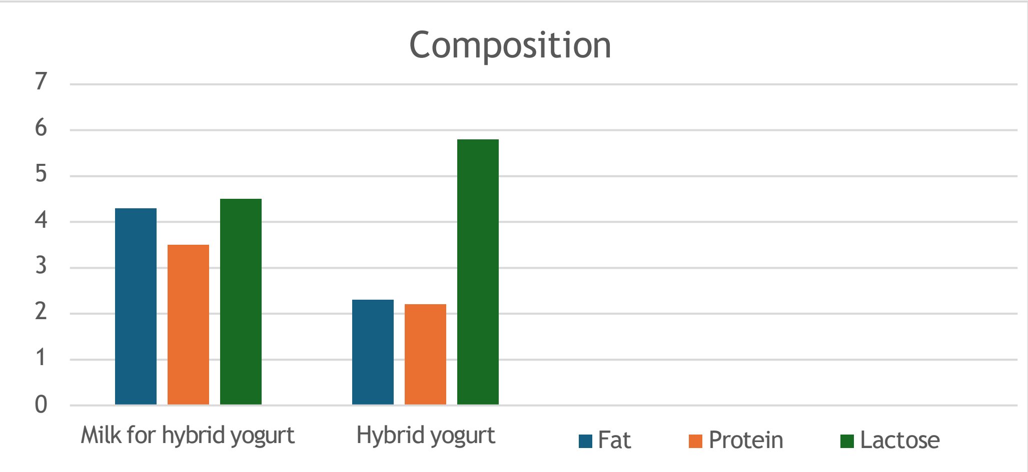

Figure 8. Graph of composition changes from hybrid milk to hybrid yoghurt

In conclusion, while the oat-cow milk hybrid yoghurt represents a significant advancement in dairy product development, its formulation and nutritional profile underscore the intricate interplay between ingredient selection, processing techniques, and consumer preferences. Continued refinement and exploration of ingredient proportions, processing methodologies, and sensory attributes hold promise for further enhancing the hybrid yoghurt's sensory experience, nutritional integrity, and market appeal. As consumer preferences evolve towards healthier and more diverse food options, innovative products like the oat-cow milk hybrid yoghurt are poised to carve out a distinctive niche in the competitive dairy market landscape, offering consumers a delightful blend of taste, texture, and nutritional benefits.

4.2. Foaming

During the production of the product, a hard layer of foam often formed on top. This happened because of the pectin in combination with the air entrainment. The pectin hardens the foam which results in forming of a hard foam layer on top of the product. To prevent microbial growth (by removing the available oxygen in the form of foam) and to maintain the highest possible quality of the product, experiments were conducted to prevent/reduce foam formation. After research and a short conversation with an employee of FACT, Willem Andries van der Valk, the product was circulated under vacuum and at a lower speed during production. The lower speed resulted in less air entrainment, and the vacuum ensured that the air in the product was sucked out after circulation. As a result, the final product contained little to no foam layer on top.

4.3. Separation of layers in Drinking Yoghurt-Whey Separation (fava bean/plant base)

Within just two days, the product inside the packaging showed separation, forming two distinct layers. Wheying-off is defined as the expulsion of whey from the network which then becomes visible as surface whey. Spontaneous syneresis, which is contraction of gel without the application of any external force (e.g., centrifugation), is the usual cause of whey separation (Lucey et al., 1998a). Spontaneous whey separation is related to an unstable network, which can be due to an increase in the rearrangements of the gel matrix, or it can be induced by damage to the weak gel network (e.g., by vibration or cutting) (Lucey et al., 1998a). Wheying-off negatively affects consumer perception of drinking yoghurt as consumers think there is something microbiologically wrong with the product. (Lee1, n.d.)

However, samples which were shaken directly after the whey separation, showed better consistency and appearance from the others, when the plastic cups opened. A penetrating look at how to prevent or reduce whey separation is by increasing the total solids content of yoghurt milk, especially the protein content.

4.4. Packaging

For the storage of the yoghurt small see-through plastic cups have been used, to be able to observe the structure of the yoghurt after a couple of days of storage.

Figure S. Packaging materials used

5. Discussion

This chapter will have discussion points on how the analysis has taken place, the importance of the product composition, how to analyze the shelf-life, how the process went regarding HACCP and which improvements need to be made.

5.1. Chemical Analysis

During this project measurements were made of the milk with the Lactoscope to provide the composition of the milk. pH measurements were also made of the yoghurt so that the drink yoghurt could get the desired pH value.

5.2. Product Composition

The nutrient composition of the product indicates the amount of nutrients within the product the consumers can have when consuming the product. The ingredients used for the final product were oats, water, raw milk from the dairy campus, a starter culture, sugar and pectin. According to the Lactoscope the whole milk contained fat content of 4.35%, 3.49% protein and 4.52% lactose. This is almost like the composition in Table 1. The composition of the milk is influenced by the feed, environment and species of the cow, all having an impact on the fat, lactose, dry matter and protein content. This result in a drinking yoghurt with different fat contents because the developed hybrid drinking yoghurt is not standardized to have a milder processed product. Oat milk contains beta-glucan which helps food digestion and uptake in the digestive system and also can also help decrease cholesterol levels in the blood. Oat milk has less fat than cow's milk resulting in a lower fat content when made hybrid drinking yoghurt instead of fully dairy. If the amount of added oat milk increases, the fat content decreases.

5.3. Microbiological and Shelf-life Analysis

Yoghurt drink is considered a product that contains living microorganisms which can improve human gastrointestinal tract function, helps digestion of lactose, reduces or prevents diarrhea and strengthens immune system. (Zubairi, September 2021)

However, during product manufacturing, bad sanitation and preparation could leads to unwanted contamination either through bacterial or yeast and mold. Yeast and mold can easily grow on foods with high sugar and salt content and cause food spoilage (Perricone et al., 2017, Altay et al., 2013). The presence of yeast and mold in milk culture turns the food to become more acidic, thus inhibits bacterial growth (Mayoral et al., 2005) It is difficult for pathogens to survive in yoghurt, because of the high acidity values (between pH 3.8-4.2). However, it can be damaged by the acidic organisms such as yeast and mold. For example, the lactose fermentation yeasts (*Kluyveromyces fragilis*) are important for yoghurt development. In addition, as a probiotic drink, the antibacterial activities of drinking yoghurts against foodborne pathogenic bacteria are also demonstrated. It is assumed that the microbiological properties are largely affected by the formulation and storage time (Comprehensive Evaluation of Microbiological and Physicochemical Properties of Commercial Drinking Yogurts in Korea, 2019 Oct 31).

An indicator to determine the shelf life of a product is by evaluating the microflora during storage. During storage, drinking yoghurt would undergo some microbiological changes in the total LAB, LAB viability, and acidity. Full dairy yoghurt contains less water than the hybrid yoghurt, and it affects total microbes and viability. Product acidity affects the growth of spored microbes and contaminant bacteria. The latter would change the characteristics of the products during storage. (T Setyawardani*, n.d.)

For drinking yoghurt to have probiotic benefits, it should contain a sufficient number of live bacteria at the time of consumption. Typically, a minimum of 10^6 CFU (colony-forming units) per gram is considered effective.

5.4. HACCP

In evaluating the Hazard Analysis and Critical Control Points (HACCP) plan for the yoghurt production process, several aspects emerged as both successful and in need of improvement.

On the positive side, the identification of critical control points (CCPs) such as pasteurization, fermentation, and storage temperatures were implemented effectively. These steps are essential for eliminating pathogens and ensuring the safety and quality of the final product. The rigorous monitoring and documentation at each CCP helped maintain consistent quality and compliance with safety standards. The training of personnel on hygiene practices and equipment sterilization also contributed to minimizing contamination risks.

However, some challenges were encountered. One significant issue was the inconsistency in maintaining the optimal fermentation temperature. Fluctuations in temperature lead to variations in yoghurt texture and taste, highlighting the need for more reliable and precise temperature control systems. During a heating step a valve has been left open that should be closed, resolves in a reduced flow and incomplete circulation, and therefore an incomplete pasteurization. The batch affected by this has been discarded. Additionally, the initial hazard analysis phase lacked a comprehensive evaluation of potential allergens, which posed a risk to consumers with food allergies.

To improve the HACCP plan, several changes should be considered. First, investing in advanced temperature control and monitoring equipment would ensure stable fermentation conditions, leading to more consistent product quality. Second, enhancing the cleaning protocols and incorporating automated cleaning systems could reduce the risk of contamination and improve overall hygiene. Finally, expanding the hazard analysis to include a thorough assessment of allergen risks would better protect consumer health and broaden the market reach by addressing dietary restrictions.

By addressing these issues and making targeted improvements, the yoghurt production process can be significantly enhanced, ensuring a safer, higher-quality product and a more efficient operation.

6. Conclusion and Recommendations

Conclusions will be made by answering the research questions with all the knowledge gathered during this project and recommendations shall be given for future undertakings regarding this project.

6.1. Conclusion

The mean objective for this research was: "Development of a dairy, hybrid or fully plant-based product destined to be sold at cafeterias of several Universities in Leeuwarden." From the results obtained by doing the research, the following conclusions can be drawn.

It is proven that a drinking yoghurt can be made from a combination of oat- and bovine milk in a 50-50 ratio. This combination is beneficial for the environment and sustainability, because production of oat milk has a lower environmental impact than bovine milk. Producing a high-quality drinking yogurt involves a series of carefully managed steps to ensure safety, consistency, and consumer appeal. Starting from, collecting and processing the raw materials (bovine milk and soaking, blending and straining oat to oat milk) to heating and homogenizing the mixture at first place and pasteurizing, cooling, adding the lactic bacteria and fermenting it afterwards, yogurt has been produced. Follow up, by adding pectin and sugar to the yogurt and stirring it, drinking yogurt will slowly start to be created, which will eventually be able to be consumed after homogenizing, pasteurizing and cooling step be completed successfully.

Based on sensorial analysis, the product does not become much thinner than the regular drinking yoghurt. This is because of the pectin and the added sugar. Overall, the texture of the hybrid was better accepted than the regular drinking yoghurt. Also, based on sensory observations, the hybrid drinking yoghurt had a sweet and mildly sour taste with a fine aftertaste caused by the added oat milk.

Foam forming was a substantial problem during the production of the drinking yoghurt. This was resolved by working under a vacuum of 0.5 bar and using a lower speed during circulation. This resulted in a final product with little to no foam layer after production.

The hybrid product also had a higher pH than the regular yoghurt (4.6 instead of 4.2). This is the result of the availability of half of the lactose in the milk, the milk – oat milk ratio was 50/50 which causes a dilution of some components under which lactose.

After some calculations and measurements, a label was produced with the nutritional facts. This label shows the amount of fat, protein, energy, salt, carbs and fibers.

Nutritional Facts	Per 100 gram	Per portion (200 grams)
Energy	357 kJ/85 Kcal	714 kJ/170Kcal
Fat	2.28	4.56
Of which saturated	1.24	2.48
Carbs	13.84	27.68
Of which sugar	11.5	23,0
Fibers	0.3	0,6
Protein	2.22	4.44
Salt	0.0	0,0

6.2. Recommendations

Utilizing ingredients such as stabilizers are recommended for follow research projects, to improve the kinetic stability of food emulsions and try to prevent whey separation, something that has been faced in our production.

In addition, citric acid can be added to the drinking yoghurt, to acquire the same pH-value of the regular drinking yoghurt or if it is desired to lower the pH than 4.2, so that the end product has extended shelf life.

For texture, adding less sugar or use a lower esterified pectin will be recommended in order to alter the balance between thickeners, sugars and lactose that can bring better desired thickness to the product. During the production of oat milk enzymes can be also added, to degrade the starch to mono or disaccharides. The pectin bonds to sugar molecules to form a network which thickens the product. When the sugar molecules are made from the starch the pectin can bind those molecules resulting in less amount of added sugar.

In addition, for follow researches, it is advisable to adjust the oat milk – bovine milk ratio in order to meet nutrition, sustainability and product characteristics demands.

Also larger volume, not see-through, sustainable plastic cups need to be used, made from polypropylene or polystyrene that ensure strength, chemical and thermal resistance and they are easy to handle.

More measurements needed to be made for this project, which results in the findings being partially or minimally supported by evidence. These results were acquired based on sensory observations.

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APPENDIX I Label

Ingredients:
Whole MILK, Water, Sugar (8%), Oat (5%), Pectin (0.8%)

Allergens:
Milk, gluten

Net weight:
200 grams

Date of production:
16-06-2024

Best before: 10-6-2024

Place of origin:
Friesland, The Netherlands

Best before, see label

FACT
Agora 1
8934 CJ,
Leeuwarden

Nutritional Facts	Per 100 gram	Per portion (200 grams)
Energy	357 kJ/85 Kcal	714 kJ/170Kcal
Fat	2.28	4.56
Of which saturated	1.24	2.48
Carbs	13.84	27.68
Of which sugar	11.5	23,0
Fibers	0.3	0,6
Protein	2.22	4.44
Salt	0.0	0,0