FIPDes

Food Innovation & Product Design

FIPDes Day 2023
International talents in Food Innovation and Product Design

Students' Book of Executive Summaries

Erasmus Mundus

Erasmus+

Congratulations to the FIPDes Cohort 10 !

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FIPDes students' book of abstract: a 10-year journey!

This is the tenth students' book of abstracts to be published

The idea of having a FIPDes day every year in September and distribute to the attendants a students' book of abstracts was born with the program exactly thirteen years ago. Built as an activity of the education program for the students, the FIPDes day is the celebration of the International Talents in Food Innovation and Product design, and it perfectly mirrors the FIPDes spirit and pedagogic approach based on professional exposure and students' empowerment. Attended by students (last and incoming FIPDes cohorts), teachers, associated partners, and the industry, it is a great opportunity for meeting, networking, and sharing!

All the attendants to the FIPDes Day have something to share.

The teachers share the enthusiasm of who have one mission i.e. offering the best, science-based and updated education in food innovation for the international students that are enrolled in the program.

The invited speakers, the industry and the associated partners share the personal experience and science behind actual challenges in food sector by showing examples, approaches, solutions, and valuable tips along with the next challenges, future opportunities, and expectations for the incoming and just graduate students.

The incoming students share their dreams mixed to fears and the enthusiasm of who feel to be finally in the right place to get the tools they need to build up their future career in the food innovation sector.

The senior (just graduate) students share their experience, the acquired knowledge, and the enthusiasm of who can finally say: "I did it! I'm ready for embracing the next challenges in food innovation and product design!". These students, during the FIPDes day, show the results of the food product development held during the second semester of the master in Ireland and disseminate the results of their master thesis through a 3-minute flash presentation, a poster session, a photo competition, and the executive summaries that are collected in a book like this.

Every year during and after each FIPDes day, it is amazing to realize how the students enrolled two years before grew up as professionals and how **the interweaving of different cultures and backgrounds, mixed to the education** delivered by the program and **based on science and team building**, is perfectly working like a **flywheel of creativity, ethics and sharing attitude which is the basis of innovation, especially in food field**.

The **23 just graduate students from the Cohort 10, are the international talents main actors in the "FIPDes Day 2023" and writers of this book**.

These **talented food innovators and designers are presented in the book by an individual** "short professional biography" including the country of origin, contacts and keywords characterizing their profile.

They come from 17 different countries: Ghana, Pakistan, Brazil, USA, France, India, Venezuela, Serbia, Cambodia, Brazil, Thailand, Mexico, Lebanon, Greece, Kazakhstan, Peru, and Albania…

It is amazing how global is the good recognition of the program and how big may be the impact of the education delivered! This needs a continue attention and a responsible attitude by the consortium partners and all the people involved in FIPDes! Key and success elements to take this responsibility are the science-based and team building approaches used in the education and all the activities promoted within FIPDes.

FIPDes activities aim to improve the open-minded and flexibility attitude of the students to the new ideas and challenges, so that they can be **responsive to the world's changing needs with creativity and competencies besides discipline and consistency** that underpin scientific evidence and approach. These features are tangible by reading the thesis abstracts collected in this book and all the abstract books distributed over the last ten years.

They show how **the thesis topics and perspectives, within the food innovation and design frame, change over time according to the hot topics and emerging needs of the moment**.

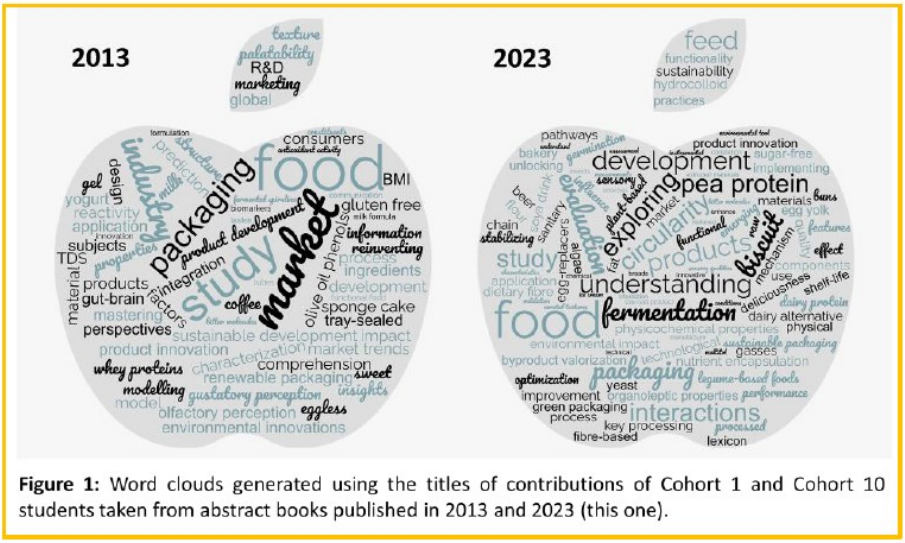

Figure 1: Word clouds generated using the titles of contributions of Cohort 1 and Cohort 10 students taken from abstract books published in 2013 and 2023 (this one).

Indeed, looking at the thesis abstracts presented by FIPDes Cohort 1 of students **in 2013** (see **Figure 1**), food appeared central besides market, packaging, and industry aspects. A general "study" approach within specific topics was applied and was mainly modelling-based to comprehend and predict the interplay between food structure, sensory, palatability and physiological aspects that drive consumers' food choices and health.

Milk, yogurt, coffee, olive oil, phenols and whey proteins besides gluten-free and eggless products were the food, components and alternative formulations that were explored the most. Finally, environmental innovations, sustainable development, and renewable packaging were already present in some of the thesis project developed.

In 2023, after 10 years and the adoption by the United Nations of the 2030 Agenda for Sustainable Development in 2015, of course food is always central, but feed also appears as study subject and it is more evident a study approach that is finalized to understanding, exploring, evaluation and development of products and packaging solutions that are based on circularity and sustainability. Biscuits, breads, buns, ice-cream, beer, algae, flour, soya, egg-yolk, dietary fibre, dairy proteins, insects, egg-replacers, dairy and legume-based besides sugar-free and low-salt alternatives are the food, ingredients and alternative formulations which are mainly explored in terms of the processing and byproduct valorization as well as functionality, and technological, physico-chemical, and organoleptic properties. Finally, **sustainability aspects seem approached across all the food chain** as germination, fermentation, byproduct utilization, green/sustainable packaging, shelf-life, environmental impact, and nutrient encapsulation to optimize nutritional aspects are explored in the projects.

In conclusion, this book contains contributions on widely disparate topics in **food innovation and product design** that fit perfectly **into the era of Sustainable Development Goals**, the current and future challenges that the FIPDes graduates and all professionals at the group and individual levels are embracing to enable a more ethical use of resources for the good of all human beings and the planet.

Cohort 10 you made a great job!

Now you are ready to navigate the food innovation and design sea by spreading FIPDes principles and method all over the world!

Good luck!

Paola Vitaglione

Influence of Breadmaking Conditions on Bread Oven Spring and Strategies to Improve the Oven Spring

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Master Thesis hosting lab/ company:
The Baking Science and Nutrition Team, Lesaffre Institute of Science and Technology

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The research delved into the baking phenomenon known as "oven spring," characterized by a substantial increase in dough volume during initial baking. The study aimed to investigate the influence of various breadmaking processes, including baking oven settings, mixing time, and hydration levels, on the physicochemical changes contributing to oven spring. To achieve this, baking profiles were created from different breadmaking conditions, and the effects on oven spring was studied using both conventional and non-conventional baking methods. The non-conventional baking process ensured uniform heating of the dough and the absence of crust, enabling a focused examination of the impact of these factors on the oven spring. The research findings revealed that lower oven temperatures and steam injection significantly enhanced oven spring. However, lower oven temperatures could lead to post-baking collapse due to a softer crust, highlighting the importance of crust formation. The non-conventional baking approach, with delayed crust formation, proved essential in achieving improved results. Additionally, the study emphasized the significance of gas bubble growth during baking, playing a crucial role in bread expansion and texture. Larger gas cell diameter was associated with a softer texture, further validating the importance of crust in regulating dough expansion during baking. The insights gained from this research provide valuable knowledge for optimizing bread production processes and achieving superior bread quality in both conventional and non-conventional baking approaches.

CONFIDENTIAL TOPIC

Improvement of Organoleptic properties of Plant Based Drink, A Dairy Alternative Beverage through addition of Ingredients

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Plant-based drinks are characterized to have unpleasant taste properties such as strong beany off note and astringency along with thin liquid texture. The project was aimed to improve the organoleptic properties of plant based drinks. Extensive Bibliographic research was performed to find out ingredients which can help achieve the target. Some potential ingredients were found and tested which improved the taste properties of plant-based drink i.e., reduced beany off note, bitterness and astringency. The texture of the product was also improved with increased thickness.

CONFIDENTIAL TOPIC

Effect of different raw materials and baking conditions on the dietary fiber content of breads

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PhD Paola VITAGLIONE

About 422 million people worldwide have diabetes, the majority living in low-and middle-income countries, and 1.5 million deaths are directly attributed to diabetes each year. Diabetes is a chronic, metabolic disease characterized by elevated levels of blood glucose (or blood sugar), which leads over time to serious damage to the heart, blood vessels, eyes, kidneys and nerves.

There are many strategies in Healthy food design to decrease the blood glucose response after food ingestion. One of them is to use nutrients that are not digested in the stomach or large intestine, and will be digested only in the colon. These nutrients are called dietary fibers.

The main objective of the thesis was to explore and evaluate which raw materials/ process conditions could lead to a bread with a higher content of dietary fibers (compared to a normal bread).

Many insights were gathered by this project that will be valuable to identify New Product Design in the future.

CONFIDENTIAL TOPIC

The Fair Circularity Principles in the Informal Waste Sector: PepsiCo Case Study in Vietnam's Informal Waste Sector (Recommendations for the Effective Integration into PepsiCo's Packaging Supply Chain)

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Profile in a nutshell:

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PepsiCo

Introduction

The informal waste sector (IWS) is a significant global phenomenon, employing millions of workers worldwide across various waste management activities. This sector is interconnected with industries like agriculture, manufacturing, construction, and households. Despite its pivotal role, informal waste workers (IWWs) often face low wages, lack of social protection, and poor working conditions due to their marginalized status. This study focuses on PepsiCo, a global food and beverage company operating in over 200 countries, and its commitment to addressing systemic risks and promoting human rights within its packaging supply chain, particularly in emerging markets.

The Fair Circularity Initiative: Empowering Informal Waste Workers

The Fair Circularity Initiative, developed in collaboration with Tearfund and major FMCG companies, including PepsiCo, aims to improve the human rights and livelihoods of IWWs. It consists of ten Fair Circularity Principles (FCPs) that emphasize recognition of waste workers, respect for their rights, engagement with stakeholders, and meaningful inclusion. This initiative seeks to foster a more sustainable and fair circular economy by reducing waste, increasing recycling, and improving working conditions for IWWs.

Research Purpose: Driving Positive Change

This master's thesis explores how PepsiCo can effectively implement the Fair Circularity Principles across its packaging supply chain in the informal waste sector of emerging markets. The research aims to generate new knowledge, challenge existing paradigms, and

provide practical recommendations for promoting sustainability, inclusivity, and human rights protection. By investigating PepsiCo's approach, this study contributes to the understanding of private sector engagement in sustainable waste management practices.

Methodology

The methodology combines qualitative exploration and systematic review processes to address the research question and objectives. Utilizing secondary data sources, including academic literature and reports, ensures a comprehensive analysis of PepsiCo's sustainability practices in Vietnam's Informal Waste Sector (IWS). The systematic literature review and case study design provide a robust foundation for generating valuable insights and recommendations for sustainable waste management.
The systematic literature review gathered recent and relevant information through a comprehensive search strategy on platforms like Google Scholar. Thematic analysis of selected sources informed insights into circular economy, Extended Producer Responsibility (EPR), and human rights. The case study focused on PepsiCo's internal policy system regarding engagement with Vietnam's IWS. Secondary data, including company reports and industry literature, provided insights into sustainability practices.

Main Findings: Strategies for Implementation

The study identifies a comprehensive set of implementation actions for each Fair Circularity Principle, providing a practical roadmap for PepsiCo to enhance its engagement with waste pickers and promote sustainable waste management practices. The principles encompass recognizing the role of waste workers, respecting their rights, engaging stakeholders, advocating for inclusion, and driving greater integration within the circular value chain. These actions range from recognizing waste workers as stakeholders and advocating for their rights to fostering local approaches and identifying and addressing barriers that hinder rights-respecting practices.

Conclusion: Paving the Path for Sustainable and Inclusive Practices

PepsiCo's commitment to sustainability, human rights due diligence, and stakeholder engagement within the informal waste sector serves as an exemplary model for driving positive change. By implementing the Fair Circularity Principles and integrating informal waste workers into their due diligence programs, PepsiCo demonstrates a proactive approach to addressing systemic challenges and promoting sustainability.

Implications and Recommendations: Guiding Business Practices

The study's implications highlight the importance of strategic alignment, stakeholder engagement, policy advocacy, operational improvements, collaboration, gender equality, local context understanding, and continuous improvement. These implications guide companies seeking to enhance their engagement with waste pickers and promote sustainable waste management practices. Recommendations for future research include conducting comparative analyses, incorporating stakeholder perspectives, and assessing long-term impacts of sustainability initiatives to drive ongoing improvement.

Conclusion

This master's thesis underscores the significance of private sector engagement and responsible business practices in addressing social and environmental challenges. PepsiCo's efforts provide valuable insights for companies aiming to integrate waste pickers, promote sustainability, and contribute to a more inclusive and circular economy. By embracing these principles, companies can foster positive change, drive sustainable development, and protect human rights within their operations and supply chains.

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The Usage of gases for Insects Consumed as Food and Feed

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Master Thesis hosting company:
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Samir MEZDOUR

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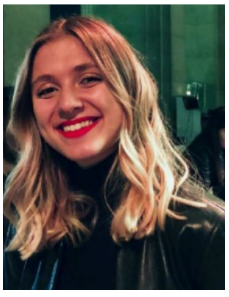

Alternative proteins have been a booming business over the past years and are expected to grow exponentially in the near future. The reasoning behind this is that the meat industry will not be able to be the main source of proteins for the population as we are running out of land to grow feed for animals. To produce the same amount of protein from crickets and from beef, 15 times more water is required when produced from the beef source, compared to the cricket source. Moreover, whether insects are consumed processed as a whole, they are thought to have the highest potential of lowering the European carbon footprint of food production and consumption. Gas could potentially be used to heat, power, produce, and modify insect production systems, making them more efficient, sustainable, or profitable. Some of those possible applications were studied.

CONFIDENTIAL TOPIC

Influence of physicochemical properties of flour on a biscuit and use of maltitol in a reduced-fat sugar-free biscuit

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Interests:
Flour transformation, director in summer camps

Master Thesis hosting lab/ company:
INRAE, CNAM

Master Thesis tutors:
Chiara Nitride

Introduction

Climate change and the world crises are negatively affecting the market of wheat flour. The principal consequences are the changes in quality and quantity of the flour available for the bakery market. The suitability of flour for biscuit production is currently assessed by using a laminating test (Qualité des blés biscuitiers français (Quality of French biscuit-making wheat) 2020). This test provides information about dough quality that cannot be transferred to alternative methods of biscuit preparation line, here the rotary moulders. More types of flour might be suitable for producing biscuits using a rotary moulder and this aspect is not considered up to today. By better using the wheat on hand, we could tackle SDG 2, 12 and 13.

More and more people suffer from chronic illnesses, including diabetes that SDG 3 tries to tackle. Maltitol can be used as a sugar replacer to produce healthier products. Even if maltitol is already used as a sugar replacer in sugar-free biscuits, its properties in a fat-reduced biscuit recipe and as a potential fat replacer in biscuits still have to be investigated.

Research objectives

This thesis had two aims. First, to determine what physicochemical characteristics of the flour are important for biscuit production using a rotary moulder.

Second, to determine the influence of maltitol usage in biscuit preparation as sugar replacer and partial fat-replacer for biscuit produced with a rotary moulder.

Methodology

For the first objective, 26 flour were characterized by their physicochemical parameters. Biscuits prepared by rotary moulders using all types of flour under consideration were evaluated for their performances measuring physical parameters after biscuit production and cooking. As the thesis is part of a larger project (Evagrain), only the moisture content and the median particle size of the flour were measured as part of the thesis. The ideal hydration, Hagberg Falling Number, protein content, alveograph and wet gluten content test of the flour were determined by the project partners and the results collated used for the statistical analysis. The biscuit production using a rotary moulder and the biscuit characterisation were part of this thesis. The biscuit production process can be seen in Figure 1.

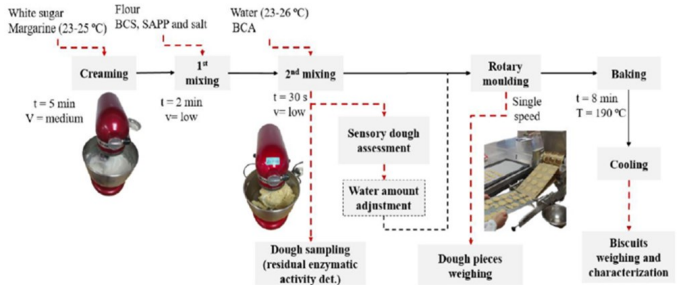

Figure 1. Biscuit production process

The measures taken were the water addition, the weight before and after baking of the biscuit, the minimum and maximum diameter of the biscuit and the hardness using the 3-point bending protocol. Variables were calculated based on those results, the loss of water mass, the maximum on minimum diameter ratio and the surface area.

For the second objective of the thesis, different recipes using maltitol were tested. Several formulations were tested:

1. reference recipe, where saccharose was replaced totally with maltitol,
2. 25% of fat reduction,
3. 25% of fat replacement with maltitol
4. 50% of fat replacement with maltitol

Ingredients	Reference	Reference, sugar replaced by maltitol	25% less fat	25% of fat replaced by maltitol	50% of fat replaced by maltitol
	Quantity (%)	Quantity (%)	Quantity (%)	Quantity (%)	Quantity (%)
Flour	57,6	57,8	63,1	57,9	57,8
Sugar	13,7				
Maltitol		13,8	15,0	20,4	27,0
Margarine	26,4	26,5	19,9	19,9	13,2
BCA	0,8	0,8	0,9	0,8	0,8
BCS	0,3	0,3	0,3	0,3	0,3
SAPP	0,4				
Salt	0,7	0,7	0,8	0,7	0,7
Water	QSP molding capacity	QSP molding capacity	QSP molding capacity	QSP molding capacity	QSP molding capacity

Figure 2. Recipes used for the maltitol trials

The same physical tests described for the firth section were performed on the biscuits with maltitol. The water activity was also determined for these biscuits as it is important for informing about stability and shelf-life. Different baking times were also tested for the recipe with 25% reduced fat.

Grubbs tests and ANOVA tests were performed to identify the significant factors (95% confidence level) and were followed by PCA tests to determine the correlations between the variables.

Results and discussions

The data collected to characterise the 26 flour were analysed to identify properties and characteristics to be used as selection criteria of flours for biscuits production using a rotary moulder. As the end goal is to use the data for the industry, the results are based on the variables important for the biscuit industry, here the maximum diameter of the biscuit (spreading), the minimum diameter of the biscuit (shrinkage) and the water addition needed to make the recipe work. The correlations found can be seen in Figure 3.

No flour variable was linked to the quantity of water that needed to be added for preparing the dough. The minimum diameter of the biscuits was negatively correlated with the protein content, meaning the more a flour contains proteins, the more biscuits produced by it will shrink. The maximum

diameter of the biscuits was negatively correlated to the median particle size of the flour, meaning the smaller the flour particle, the more the biscuit will spread. As shrinking is not wanted by the industry, flour with a lower percentage of proteins is more suitable. Spreading of the biscuit can be suitable depending on the recipes chosen by the bakery industrials. By selecting flour with bigger or smaller particle sizes bakers could vary the spreading accordingly.

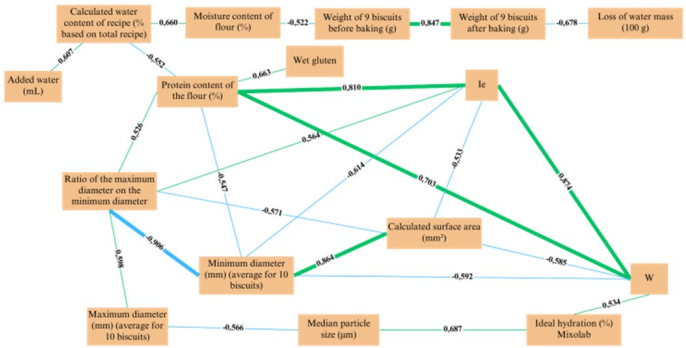

Figure 3. Correlation graph for the flour trials

For the maltitol trials, the biscuits using maltitol as a fat replacer gave poor results. The dough was hard to process through the rotary moulder, the biscuits showed a high amount of cracks and an oval shape rather than a round shape after baking and were hard to bite through. The recipe using maltitol as a saccharose replacer in a reduced in fat recipe was more promising. The correlation found for the recipes are shown in Figure 4.

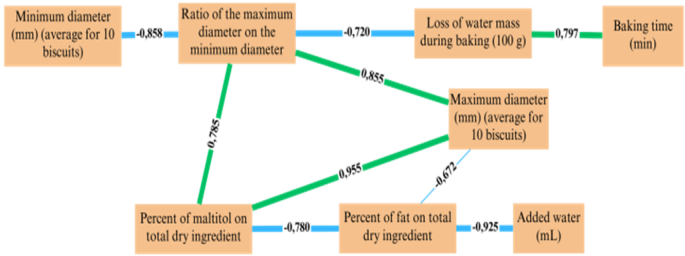

Figure 4. Correlation graph for the maltitol trials

The water that needed to be added was negatively correlated to the fat content, meaning the less fat in the recipe, the more water needs to be added. This makes sense as margarine contains a high amount of water. The minimum diameter of the biscuits was not explained by any of the variables, which made sense as this variable is linked to the protein content of the flour and the same flour was used for all the maltitol recipes. The maximum diameter of the biscuit was positively correlated to the maltitol amount of the recipe, meaning the more maltitol is used, the more the biscuit will spread, which can be off-putting for the industrials depending on what type of biscuits they want to produce, so using a high amount of maltitol could not be suitable for industrials.

As a lot of water had to be added during the process, the biscuit were still soft after baking for 8 minutes and had a high water activity. To tackle this issue, the baking time was increased. The results can be seen in Figure 5.

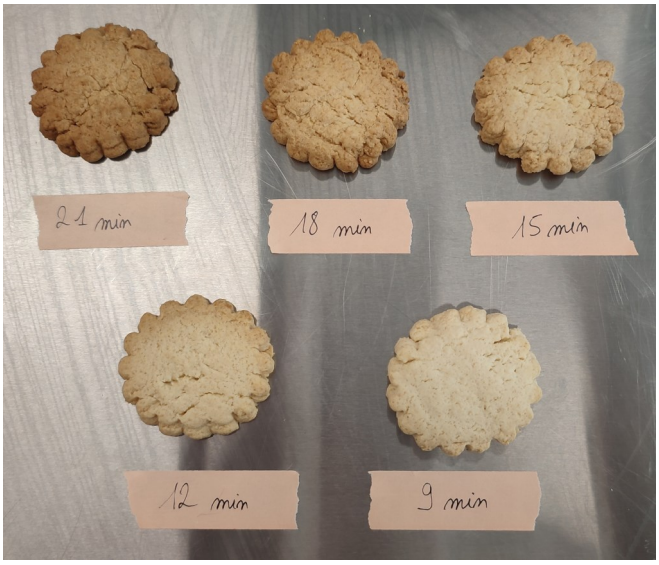

Figure 5. Biscuits made with the 25% less fat recipe after different baking times

After 12 minutes of baking, the water activity of the biscuits was similar to the water activity of the reference biscuits. The biscuits at 12 and 15 minutes baking time had a more golden colour, probably due to carbonization, as maltitol is not a reducing sugar and hence doesn't undergo the Maillard reaction. After 18 minutes of baking, the biscuits had a carbonized off-flavour not suitable for hu-

-man consumption. By adapting the baking time, industrials could produce more appealing biscuits with an increased shelf-life and suitable for diabetics.

Conclusion

All the flours were processable with the right amount of water addition. No correlation could be found between the flour composition and the added water, multifactorial correlation tests should be performed in the future to try to find correlations. For the biscuit industry using rotary moulders, flour with a low protein content seem more suitable regarding the shrinking. Regarding the spreading, if the industrials want a higher spreading, they should use flour with smaller particle sizes.

Maltitol is not a suitable fat replacer in biscuits but gives promising results as a sugar replacer in a fat-reduced biscuit. The baking time should be adjusted accordingly, in order to have a low water activity and a more golden colour.

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Understanding Mechanism of Interaction between Yeast and Beer Bitter Molecules

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Spent Brewer's Yeast (SBY) is the beer brewery industry's high-value side stream. However, its applications are limited by the presence of hop's bitter acids. Hops are used in beer to give the characteristic bitterness. Technologies to debitter SBY exists, which mostly use processes which are expensive and an environmental hazard. Yeasty has developed a process to debitter SBY and therefore valorise this valuable side stream in a more economically and environment-friendly way.

This thesis aimed to understand the nature of the interactions between the bitter molecules of hops and the yeast in a bid to gain an in-depth understanding and therefore optimise the process of debittering accordingly.

Studies done as a part of this thesis showed that various physio-chemical factors had a highly significant effect on the interactions of the hop's acids with the yeast cells.

There was therefore a hypothesis formed about the mechanisms of interaction of the hop's acids with the brewer's yeast. This study also attempted to characterise samples of SBY from breweries using a cheap, rapid and greener technique compared to HPLC-MS.

CONFIDENTIAL TOPIC

Optimization and understanding of interactions leading nutrient encapsulation performance in Russian doll structured feed

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Introduction

VivoHatch® feed, designed under a patented Russian-doll encapsulating architecture contains, simultaneously, in a nutrition-aimed product, different physicochemical systems such as Pickering double emulsions and cross-linked biopolymer-gelled complex coacervates. Innovative, sustainable materials such as clay, grape extract, chitosan, among many other ingredients, are part of their structure. Such elaborated system was ideated to reinforce the encapsulation of diverse nutrients and bioactive ingredients within the product. To the best of our knowledge and after literature research, encapsulating systems with modified-Montmorillonite-stabilized Pickering double emulsions reinforced by a surrounding complex coacervates bulk in a Russian doll fashion have not been reported and are as innovative as complex.

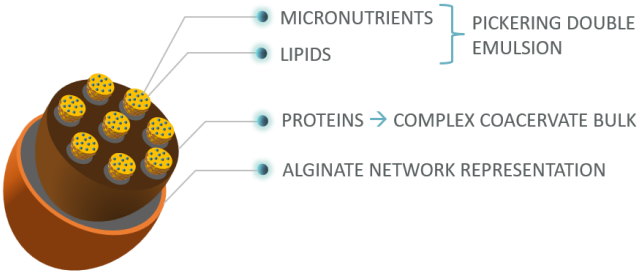

Figure 1. General scheme of Russian doll patented encapsulating structure in VivoHatch®. Diverse physicochemical

Research objectives

The aim of this thesis was double: on one hand, it was to optimize the encapsulation performance of fish protein hydrolysate (FPH) in a complex coacervation system and the encapsulation performance of hydrosoluble and liposoluble nutrients in Pickering double emulsions, both within VivoHatch® architecture. The latter, through

the optimization of Pickering double emulsions as delivery systems, considering the encapsulation performance could be improved due to smaller, more stable, more filled, and more homogenous encapsulating droplets. On the other hand, the aim was to understand the interactions that drive the performance in these encapsulation systems. Focus in this summary will remain on Pickering double emulsions as delivery systems.

Methodology

Pickering double emulsions were prepared according to Fig 2. Clay and lecithin concentrations varied according to Table 1 for the evaluation of the impact of their concentration in the droplet size and its stability performance.

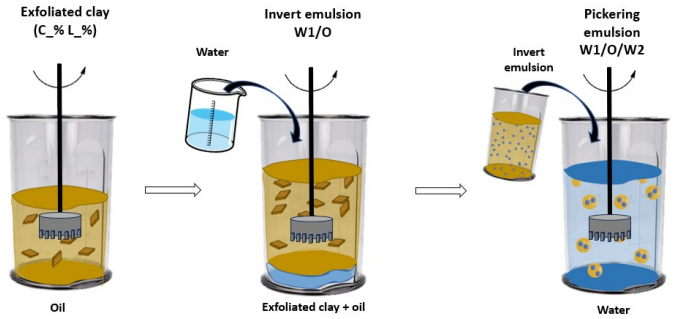

Figure 2. General preparation scheme of W/O/2 Pickering emulsions under study.

Table 1. Orthogonal Taguchi array of studied variables for Pickering emulsion optimization study.

Essay	Clay (%)	Soy Lecithin (%)
1	C1	L1
2	C1	L2
3	C1	L3
4	C2	L1
5	C2	L2
6	C2	L3
7	C3	L1
8	C3	L2
9	C3	L3

C1, C2 and C3 represent increasing concentration of clay/oil ratio. L1, L2, and L3 represent increasing concentration of soy lecithin (% surface coverage). True values are reserved for confidentiality reasons.

Herewith, droplet size distributions were evaluated in the W1/O/W2 and their correspondent W1/O emulsions after 24 h and 120 h through micrographs and subsequent particle size analysis using an image processing program (binary image processing) where samples were prepared by diluting 1 mL of sample in 10 mL of water, or oil, correspondingly. 1-2 droplets of the prepared sample were pipetted onto a glass slide and covered by a cover slip. Droplet representative sampling was achieved by taking >4 pictures of different random areas of the sample under the microscope which represented >14000 particles measured. The droplet size distributions were calculated through surface area determination of each particle and were transformed into volume cumulative particle size distributions.

Results and discussions

W1/O emulsions were studied considering their improvement to be one of the main approaches for encapsulation performance optimization. Droplet size distribution data and curves were compared after 24h, and size and dispersity, product of most probable coalescence events, was observed with the increase in clay concentration and time, clearly depicted in the polymodal and polydisperse curves. After 120 h, the smallest, most homogeneous and stable droplet sizes obtained where under C1% L1% conditions (Fig. 3), which in time would mean a lower coalescence. Working with lecithin concentrations of L1% and a low clay/oil ratio (C1%) seemed to give the best stability performance.

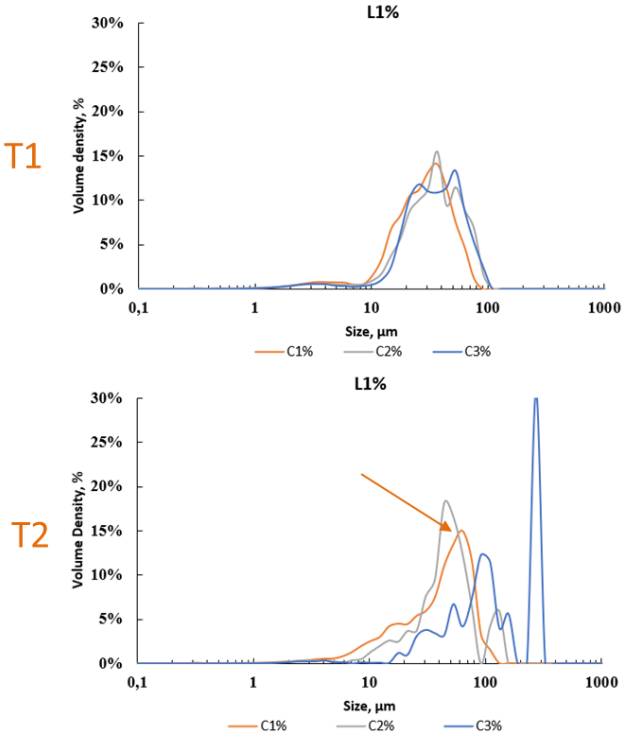

Figure 3. Droplet size distribution of Pickering invert emulsions after 24 h (T1) and 120 h of preparation (T2).

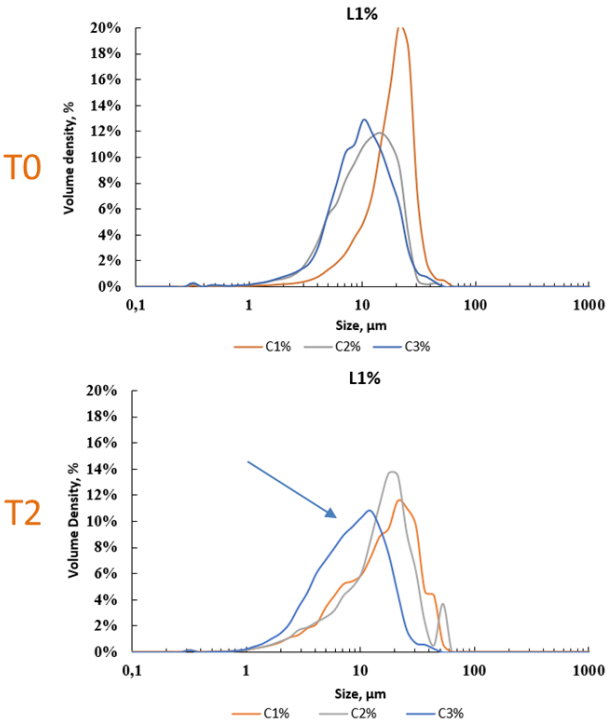

Figure 4. Droplet size distribution of Pickering double emulsions immediately after prepared (T0) and 120h of preparation (T2).

In W/O/W, a long-lasting, filled and small droplet size was mainly desired and constituted a goal in the current research study. Even though not such dispersity in droplet size was evidenced as in W1/O, W/O/W were not fully stable under all conditions tested (Fig. 4). Opposite to W1/O, a highest clay/oil ratio (C3% L1%) seemed to give the best stability performance. A leaking extent study coincide with the previous conditions for the essay with the least leaking of all, which confirmed the stability performance at C3% L1% concentrations. Fluorescein salt was used as an indicator of leaking, where it was hypothesized that those systems with higher encapsulation efficiency would leak in a lesser extent.

The results led to the optimization of VivoHatch® current process and formulation with a new two-step modulation procedure based on the results obtained. Structure and size improvements in the adjusted formulation were confirmed (Fig. 5) where, in W1/O, a clear reduction in size was noticed, and in W1/O/W2, more filled O/W droplets were evidenced, in contrast to the old formula.

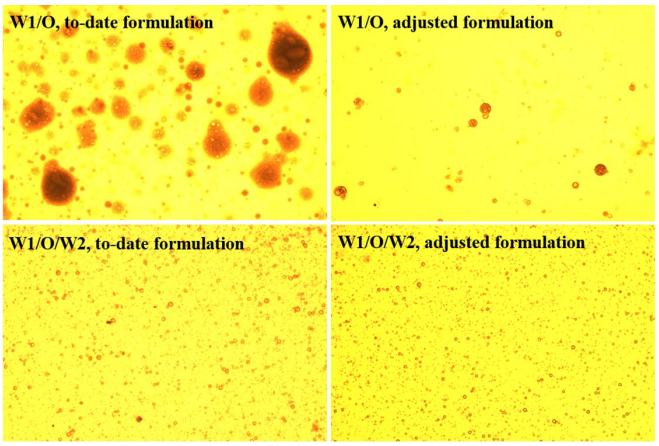

Figure 5. Optical micrographs of VivoHatch® Pickering emulsions, immediately after prepared, x10 magnification.

The defined double emulsion structure was further visualized and confirmed through confocal microscopy images displaying the adjusted Pickering W1/O/W2 emulsions in VivoHatch® (Fig. 6), wherein Nile red liposoluble marker was used to fluorescently label the oil phase. The use of this indicator made it possible to discriminate the different phases of the double emulsion and to note the W1 drops evidently separated within the oil phase (O), as well as the clear-cut oil drops dispersed in the continuous W2 aqueous phase.

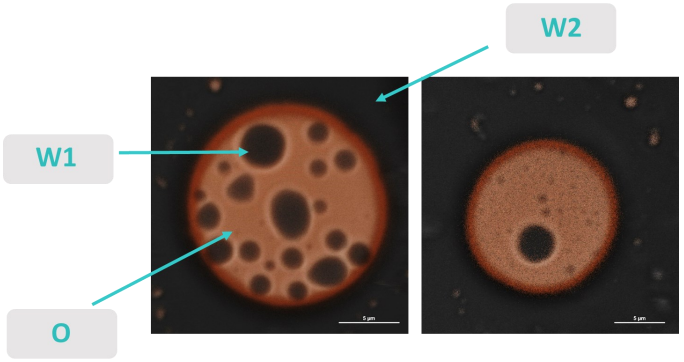

Figure 6. CLSM images of W/O/W Pickering adjusted emulsion, x100 magnification.

Conclusion

The optimization of Pickering double emulsions was possible by modification of the surface and wettability properties of MMT particles thanks to soy lecithin molecules, where higher stability performance and smaller droplet sizes were achieved. The results gathered allow the comprehension of the impact of lecithin and clay concentration on the wettability of clay particles in the emulsions under study: A lower clay concentration resulted more favourable for W1/O emulsions, whereas higher clay concentrations resulted more favourable for the O/W2 interface of the W1/O/W2. This was understood from a higher hydrophobicity of the colloid particles in the former emulsions, product of a higher surface coverage, in comparison to a lower hydrophobic property in the colloid particles in the latter, product of a lower surface coverage, which coincides with the literature available.

The improvements attained might represent a positive impact regarding the nutrition profile of VivoHatch®, as smaller, more stable, and homogeneous lipid droplets could involve a higher bioaccessibility of hydrophobic bioactive compounds (Porter & Wasan, 2008; Xiao & Lewis, 2012), with an increased protection of hydrosoluble vitamins. Most interactions leading the encapsulation technologies in VivoHatch® were further understood.

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Varnishing of Fiber-based Closures

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Introduction

Marine pollution from plastics has been a growing concern. Among the many wastes that end up in the ocean, beverage containers made of plastic which is non-biodegradable are among the most frequently dumped wastes entering the ocean. These plastics have a long life span and can take centuries to degrade. The ingestion of plastics by marine animals is one of the most serious environmental impacts on the marine environment. Hence, policies are being implemented to reduce the use of single-use plastics.

Producers and consumers have also observed an increase in awareness of the environmental impact caused by packaging, the need for recycling, and the value of eco-design. Retailers and brands are under pressure to fulfil these requirements. Thus, packaging industries are making a shift to find packaging that is sustainable. BOC is one such Swedish sustainability start-up that is revolutionizing the packaging sector by creating fiber-based screw closures and lids to replace plastic.

Fiber-based packaging is gaining importance due to its recyclability and biodegradability. It has also been proven to have less environmental impact as compared to metal or plastic in terms of carbon emission and effect on climate change. One challenge is the natural porous and hydrophilic nature of fiber-based materials that prevent their application in certain products that require good barrier properties. To improve the technical performance, coating is required. Therefore, the focus of the study is the varnishing of fiber-based closures to attain water barrier properties.

Research objectives

- To analyze the type and amount of varnish to apply.
- To analyze the water barrier properties of the above-coated closures.
- To study the pros and cons of coating processes.
- To evaluate and compare the recyclability of the coated (selected) closure with the uncoated.

Methodology

The materials used in this project are cellulose fiber-based closures (produced by BOC) and nine varnishes from different suppliers. The investigation began with testing the varnishes by applying on the closures using a Sames Kremlin SAS Spray gun. Due to technical complications in the equipment, brush coating and dip coating were adapted to evaluate the performance of varnishes while a new spraying equipment was being arranged. After coating, the dry coat weight of the samples was calculated using the following formula:

$$\text{Dry Coat weight} = \frac{(final\ weight - initial\ weight)}{surface\ area\ of\ sample} X\ dry\ content\ \%$$

Once the new spraying equipment arrived, the varnishes that showed good performance were tested using the new spraying equipment from Spraying Systems to select the most desirable, viable, and feasible varnish.

The coated samples were analyzed for contact angle measurements using an Oscilla contact angle goniometer, to measure hydrophobicity. The penetration time of the droplets was noted. The repulpability trials were conducted at the lab and facility of Karlstad University. The equipment used for the repulpability are: (a) disintegrator to repulp the material, (b) Somerville screening equipment with 40µm diameter pore mesh to screen the accept and reject material, (c) MESSMER BUCHEL Handsheet former and Lorentzen & Wettre sheet press to make the handsheets and (d) Memmert drying oven to dry the handsheets.

The visualization of the results and the variance in coat weight, contact angle, and penetration time were determined through graph builder tool and multiple variance analysis (ANOVA) using the JMP Pro 16 software respectively.

Results and discussions

Visual Observation:

V1, V2, V5, V6, and V8 showed good barrier properties, transparent color, and a smooth texture (see Figure 1). V3, V4, V7, and V9 showed undesirable results like brown color of the varnish, crystallization, rough texture , and poor water barrier property.

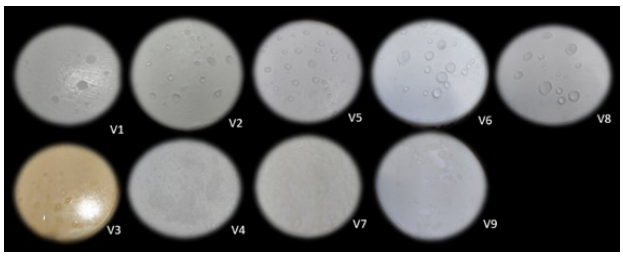

Figure 1. Visual appearance of the coated closures. Row 1 : Acceptable results. Row 2: undesired results.

First screening step:

In the quantitative analysis, V1, V2, V5, V6, and V8 fulfil the chosen minimum criteria. Which is a coat weight below 20g/m^2, contact angle of 90˚ and above, and a penetration time of 20 min and above (see Figure 2 & 3). The selected varnishes will further be tested using the new spraying equipment.

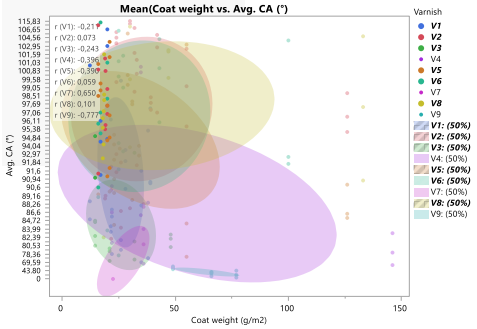

Figure 2. The scatter plot of mean coat weight vs contact angle.

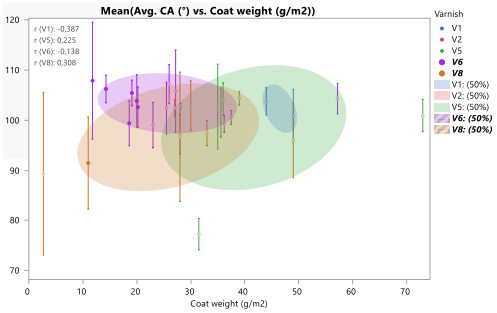

Figure 3. The scatter plot of mean coat weight vs penetration time

Second screening step:

V6 showed relatively low coat weight (11.8, 20 and 14.3 g/m^2) with high contact angle measurement (107.9º) and relatively long penetration times (82.6 and 23.3 min) respectively. V8 while using a lower coat weight (11g/m^2) showed high contact angle measurement (91.46 º). (see Figure 4 & 5).

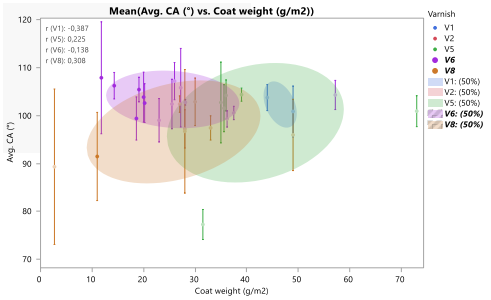

Figure 4: The scatter plot of coat weight vs average contact angle showing the final selected varnish.

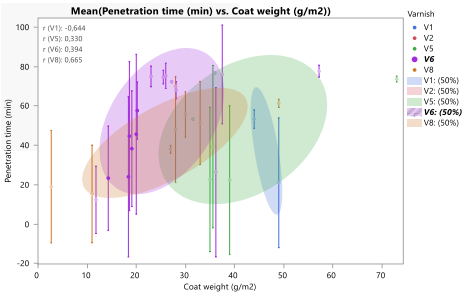

Figure 5: The scatter plot of coat weight vs penetration time showing the final selected varnish.

Repulpability:

The V6 coated lids with a coat weight of 12.9 g/m^2 defibrillated for 10 and 20min at 3000rpm had a yield of 80.5 and 85.6% respectively. Whereas the yield for uncoated lid had yield of 86% for the same defibrillation.

The sheet adhesion for the handsheets was absent, which implies there was no damage or breaking when the sheet was simply separated from the support and gloss sheet for both coated and uncoated lids. However, the rejected material from coated lids after screening was slightly blue which requires further research to study the phenomena or its recyclability (see Figure 6)

Figure 6: Light blue color of the reject material from coated lid.

Coating technology:

As hypothesized, spray coating from Spraying Systems equipment helped in achieving the results. It was easy to handle, possible to attain low coat weight by regulating parameters like airflow, liquid flow, and size of the droplet due to the availability of various nozzles.

Conclusion

Nine varnishes and three coating processes (spraying, dip, and brush coating) were evaluated. Varnishes selected through qualitative and quantitative analysis matched. The varnishes were selected through two screening steps.

V1, V2, V5, V6, and V8 were selected in the first screening step. The selected varnishes were tested using the new spraying equipment.

In the second screening step, V6 appeared to be the most desirable varnish as it showed both high contact angle and long penetration time while using a lower coat weight. V8 showed good results in using lower coat weight and high contact angle. Both samples can be used based on the end application.

The spraying equipment from Spraying Systems appears to be a potential process for implementation, although scaling up is yet to be evaluated.

Repulpability of the uncoated and V6 coated lids had yield of 86% and 80% at 10 min defibrillation respectively. For 20 min defibrillation, the uncoated and coated lids showed a yield of 86% and 85.6% respectively. Therefore, samples coated with V6 are recyclable.

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Key processing steps, their variability and influence on product chemical and physical characteristics, and product quality features of ice cream

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Ice cream is a multiphase system comprising of air, fat, and ice crystals dispersed in a highly viscous, concentrated, unfrozen solution. The structure of ice cream is shaped by various processing steps and ingredients utilised during the manufacturing process, which can impact the qualitative aspects of the final product.

During the internship, an in-depth exploration was made into the manufacturing process of Häagen-Dazs ice cream. The emphasis was on analysing the critical stages of the process and their influence on the chemical and physical characteristics, as well as the overall quality of the product. The ultimate objective was to identify any variations between the production lines, evaluate their level of impact, and determine if they have any effect on the ice cream's quality performance.

In order to accomplish this goal, extensive data was collected and analysed with great care and attention to detail. Various factors that played a role in the observed differences were closely examined in a systematic manner. The conclusions drawn were crucial in identifying a connection between the manufacturing process and the properties of the product.

CONFIDENTIAL TOPIC

Effect of salt reduction on the texture and sensory quality of wheat flour tortilla wrap

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Introduction

With the rising concern on public health due to daily high consumption of salt link to increasing the risk of cardiovascular diseases (Wang et al., 2020), there are many global initiatives happen around the world to act on the issue. One of the most effective strategy to reduce the salt consumption and improve public health is by introducing salt reduction guideline for food industry to follow (Webster et al., 2011). For instant, the "UK Salt Reduction Targets for 2024" issued by the Public Health of England in purpose to guide food manufacturers to reduce the salt content in their products according to different categories (Nicholas et al., 2020). As a collaboration work with **Freshways Food Company** (Ireland), to bring the current nine wrap products into salt compliant by the end of 2024, the salt reduction in wheat flour tortillas was taken into account.

Two main ingredients responsible for wheat flour tortillas quality are wheat flour (with high protein content) and the suitable leavening agent such as sodium bicarbonate (F. Bejosano & Novie Alviola, 2015). On the other hand, there are not many study on the salt function in wheat flour tortillas. The salt function in fermented bakery products are well know on its ability to control on the yeast fermentation during dough forming. This reaction relates strongly to the texture quality of the finished products, by decreasing the production of gas in the dough, and provide more fibrous gluten structure (more elastic bread) in the bread (Silow et al., 2016). Wheat flour tortilla is not a fermented bakery product, but it also have a similar glutenous structure (R.D. Waniska, 2015).

Hence, the hypothesis is that the reduction of salt in the tortilla recipe might have impacts on the product's sensory and texture quality too.

Research objectives

To confirm on the hypothesis, this study was conducted to study the impact of added salt reduction in the current tortilla recipe compared to the reference samples (no salt reduction) by looking at parameters as below:

- Sensory quality (descriptive & triangle test)
- Texture quality (subjective rollability test)
- Additional parameter: water activity in correlation to sensory and texture quality

Methodology

- Tortilla samples as shown in below table are produced by a local flat-bread manufacture in Ireland to supply for **Freshways Food Co.,** on the same day of production to the next day delivery the latest.

No	Sample Description	Added salt level	Added salt per 100g	Sample Codes
1	Reference sample: Plain wrap	100%	0.58g	Ref. P
2	50% added salt reduced plain wrap	50%	0.29g	P-50%
3	75% added salt reduced plain wrap	25%	0.145g	P-75%
4	Reference sample: bar-marked wrap	100%	0.58g	Ref-BM
5	50% added salt reduced bar-marked wrap	50%	0.29g	BM-50%
6	75% added salt reduced bar-marked wrap	25%	0.145g	BM-75%

Table 1. .Samples preparation list.

- Descriptive sensory test:

Conducted with 5 trained panellists with the 6 samples of toritllas. Trained panellists evaluated on 9 sensory attirbutes by the descriptive word choice then give the scores of each attribute between 1 to 15 (1 the least intensity, 15 the highest intensity).

- Discriminative sensory test (Triangle test):

Conducted with 30 random panellists, on 4 pairs of samples (Ref.P vs P-50%, Ref.P vs P-75%, Ref.BM vs BM-50%, Ref.BM vs BM-75%). The samples were prepared in form of wrap product (southern fried chicken recipe) as the intended use of the tortilla. The results are the analyse by using the triangle test statistical table (Nia, 2019).

- Rollability test

Conducted with 10 trained panellists to wrap the six samples of tortillas with 30g of iceberg lettuce as fillers, then evaluated each samples from score 1 to 5 shown in the figure 1 (1=unrollable, break easily, cannot hold filling, 2=creaking and breaking imminent on both sides, 3=craking and breaking on the surface, 4-sign of cracking but no breaking, 5=no cracking, roll easily).

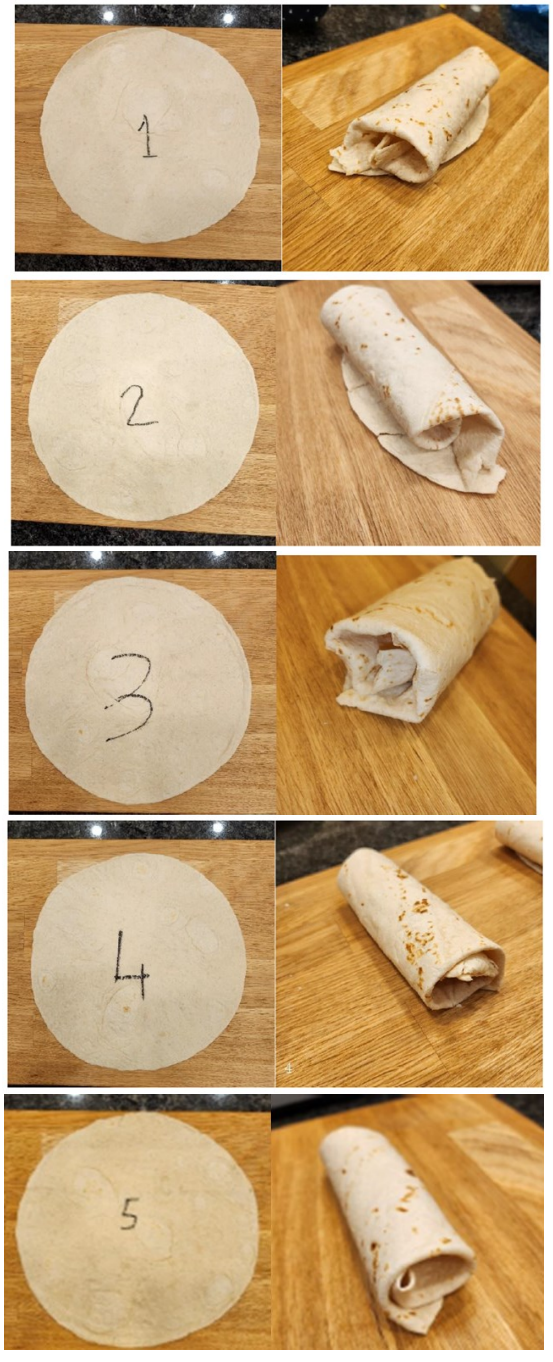

Figure 1. Scoring list for rollability test.

♦ Water activity measurement:

Water activity (Aw) of the samples were measured by using water activity meter Aqualab PRE robust model, where each sample was cut (1inch square) from three different areas (1 center, and 2 edges) for mean values.

♦ Statistical anaysis:

One-way analysis of variance (ANOVA), α = 0.05, by SPSS version 23 (2015) were used to find significant differences between the sample groups (salt levels, and process plain wrap, barmarked wrap) and their mean results.

Results and discussions

♦ Descriptive sensory test:

All six samples did not show significate difference (P>0.05) for all the attributes **(figure 2),** indicating that added salt at level below 25% of the current recipe does not affect the sensory and texture quality of the tortillas.

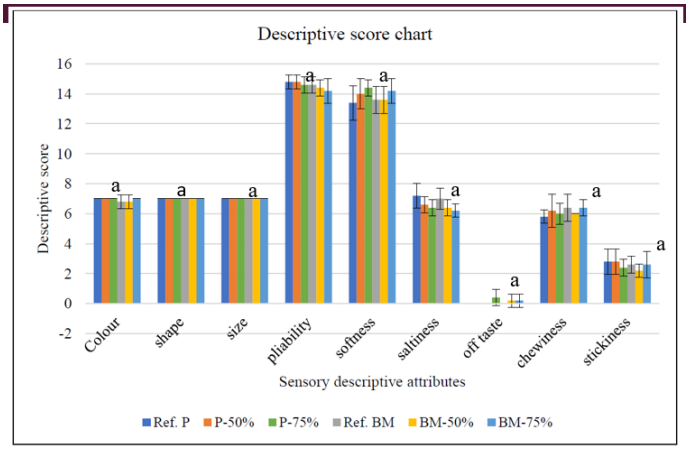

Figure 2. Descriptive scoring bar-chart

♦ Triangle test:

According to triangle test statistical table (Nia, 2019), for 30 panellists test, requires to have minimum 19 correct answers to confirm significant different between samples (α = 0.1). According to the pie charts (**figure 3)**, the correct answer for all the 4 pairs are from 9 to 12. This means there were no significant differences between all pairs. However, this result could be influenced by the filling flavor profiles. As mentioned in the review by Kilcast and Ridder (2007) that the compensation of the flavor in the salt reduced product can be achieved by using the component responsible for flavor delivery such as herbs, spices, lemon, onion/ garlic, vinegar or other acids. The spices in both chicken pieces and mayonnaise, including pepper, paprika extract, mustard, vinegar, etc…, in the wrap are more than enough to compensate on the changes of salt levels in the wraps that altered consumers perception to notice the difference between the products.

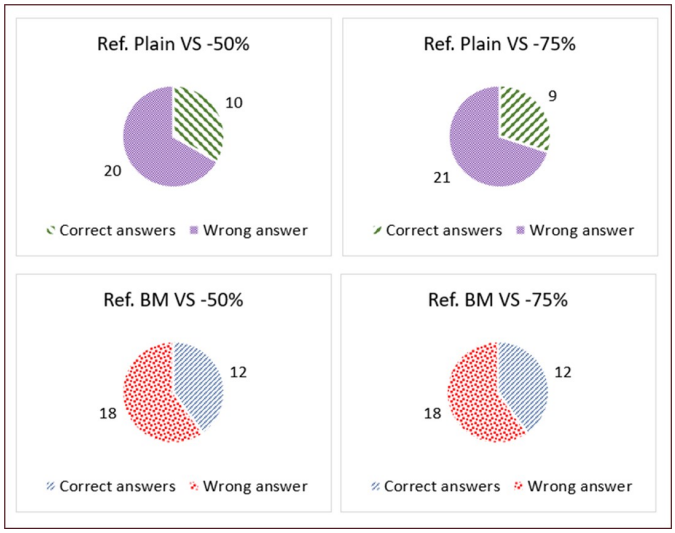

Figure 3. Pie charts showing results from triangle test.

♦ Rollability test

There was no significant difference found between the six sets of samples on both day 3 life samples and day 8 life samples (p>0.05) as shown in **figure 4**. The results are in accordance with the descriptive sensory scoring. However, there is a significant difference found between the rollability scores for 3 days life samples and 8 days life sample (p<0.05).

Similarly in the study from Bejosano et al. (2005), it is indicated that wheat flour tortillas increase in staleness between 1 and 8 days of storage and decrease in their rollability score due to the retrogradation happened during storage. In the case for Freshways Food Co., tortillas are never stored longer than 3 days from their production date, the

finished wraps products require extra 4 days in the market place. However, it is interesting to observe further the rollability score in between storage day 1 to day 8.

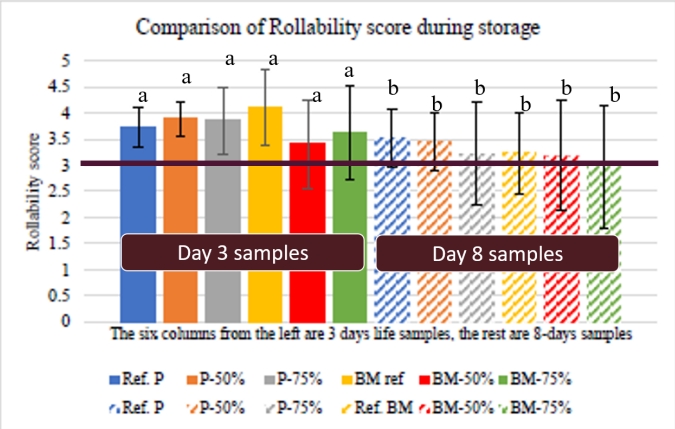

Figure 3. Scoring results for rollability test.

♦ Water activity measurement:

Table 2 show results from Aw measurement that plain tortillas have no significant difference ($p>0.05$) among the 3 levels of added salt samples, whereas the bar-marked tortillas show an increase trend of the Aw value. This trend can be a result of the heat during bar-marking process that was absent in the plain wrap samples. This is logical as the concentration of salt decrease the moisture content in the samples should increase along with the water activity values.

Samples	Aw value	
	Mean*	± SD
Plain ref	0.9237a	0.0284
-50% plain	0.9443a	0.0107
-75% plain	0.9377a	0.0115
BM ref	0.9323b	0.0076
-50% BM	0.9433c	0.0116
-75% BM	0.9583d	0.0081

Table 2. Water activity results for six samples

According to study from Waniska (2015), the increasing of Aw in wheat flour tortillas can increase the stickiness texture that lower the quality of tortillas and cut down shelf-life of the product.

Conclusion

Overall, the result in this study indicates that reduction of added salt in the wheat flour tortillas at the two different levels 50% and 75%, both do not have any impact on the sensory quality as proven by the sensory analysis descriptive test and discriminative test. However, this result could be influenced by the filling when its ingredients contain salt and spices.

The same goes for texture quality of the products was not influenced by the added salt above 25% as demonstrated by the subjective rollability test. This indicates that the added salt in the current tortilla recipe can be reduced from 0.58g/100g tortilla, to 0.145g/100g tortillas, for which this level of change will not impact the wrapping quality of the product within 3 days of storage.

This result is very positive for the company since it already supports the new salt reduced tortillas up to 75% and does not require to continue to a higher cost and time-consuming trial on the change of tortilla improver. The salt reduction at this level also moved the current wraps products that are not salt compliance with the new salt target for the UK into compliant status instead **(table 3).**

Wrap products	Salt Content (g / 100g)	Filling category	Salt reduce 50% in tortilla	Salt reduce 75% in tortilla	Salt target/100g
Product 1	0.89	Low salt	0.6289	0.4985	
Product 2	1.15	Low salt	0.8889	0.7585	<0.83g
Product 3	1.1	Low salt	0.8389	0.7085	
Product 4	1.5	High salt	1.2389	1.1085	<1.43g
Product 5	1.08	Low salt	0.8189	0.6885	
Product 6	0.93	Low salt	0.6689	0.5385	
Product 7	1.04	Low salt	0.7789	0.6485	<0.83g
Product 8	0.94	Low salt	0.6789	0.5485	
Product 9	0.98	Low salt	0.7189	0.5885	

Table 3. Current nine wrap product and their salt target 2024 compliant status at different salt lev-

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Study of an innovative process to manufacture functional algae fibers for food application from *Ascophyllum nodosum* by-product valorization

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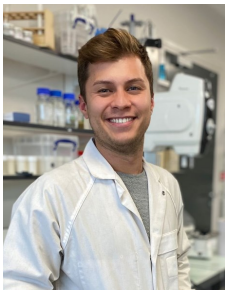

In the context of by-product valorization, the study sought to explore the functionalization of a side-stream industrially generated from an agri-ingredient manufacturing, as a clean label texturing ingredient for food application. The ambition of Algaia to valorize 100% of the seaweed consumed for their products production and a growing demand from the consumer side for healthier and functional foods were the main driving forces for this research.

The algal by-product, composed of chopped *Ascophyllum nodosum*, which is food grade and a natural source of dietary fiber, was mechanically or lightly chemically treated, aiming to improve its functional properties such as viscosity, water holding capacity, swelling capacity, and emulsification activity. Besides the evaluation of the functionalization level of each tested technique, physical and nutritional modifications were also tracked.

The most performing treatment could enhance seven times the viscosity, double the water holding capacity and swelling capacity of the algal biomass, and increase the emulsion stabilization. Additionally, it also provided positive impact on the material's color, turning it lighter. Figure 1 exemplifies the better emulsion stability and the color change.

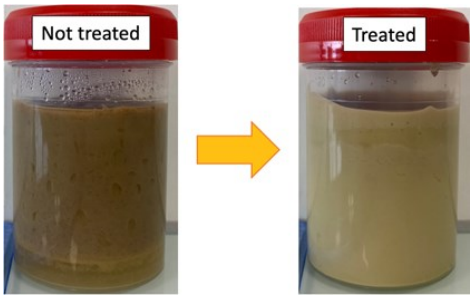

Figure 1. Improvement of emulsion stability and color due to by-product treatment

The meaningful insights and improvements obtained in terms of hydration properties and emulsification suggest a promising future for the product under development and will be of great value for the following investigation steps. Further work regarding clean label bleaching and deodorization needs to be carried out.

CONFIDENTIAL TOPIC

Mouthfeel Assessment of Tetra Pak Paper Straws: Exploring the Correlation between Instrumental Measurements and Sensory Evaluation

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Introduction

Plastic pollution has become a significant concern in recent years, which one of the key contributors is the use of single-use plastic products (SUPs). Plastic straws, in particular, have attracted attention due to their high levels of consumption but poor recycling rate, leading to environmental degradation and threats to marine life (Tembo Paper, 2020). To tackle this issue, the European Union has implemented the Single-Use Plastics Directive to restrict the sale of such products (European Commission, n.d.).

Considering the regulatory changes and the increasing demand for sustainable solutions, Tetra Pak has taken on a mission to replace plastic straws in their portion-size carton packages with environmentally friendly alternatives. The introduction of paper straws is a significant step towards reducing waste and promoting a cleaner environment (Tetra Pak, n.d.). However, there may be challenges in accepting paper straws due to concerns about how they feel in customers' mouths that are difficult for them to accurately describe.

It is, therefore, important to identify consistent and objective approaches, such as instrumental measurements, that contribute to a broader understanding of mouthfeel and align with customer experience. This knowledge will enable the development team to create paper straws in accordance with customer expectations and preferences.

Objective and Research questions

The testing methods were developed in this study with the aim of investigating the useful correlations between subjective sensory perceptions and objective instrumental measurements of the mouthfeel on paper straws. A strong and significant correlation between objective and subjective measurements could mean that objective testing methods can be used as a quick and effective tool to measure relevant subjective mouthfeel perception of paper straws. Therefore, two research questions were defined:

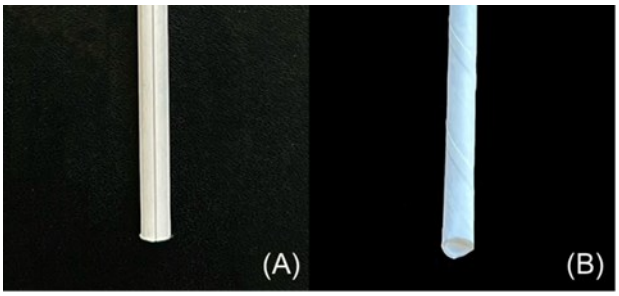
1. Are there any strong correlations between the objective instrumental measurement and subjective sensory analysis related to the mouthfeel on paper straws?

2. Which objective instrumental measurement can predict the subjective attributes of the mouthfeel on the paper straws?

Material and Methodology

Six different types of paper straws (R, SC, CC, W9C, W12C, and CM) were evaluated in this study. The first five variants were provided by Tetra Pak, while CM, a commercial straw, can be found in the existing market. All Tetra Pak paper straws are made from the same paper substrate, with differences perceived in seaming orientation and the coating material (The R variant is only an uncoated one). Clear differences between Tetra Pak straw and commercial straw are the structural design and the type of coating material. Tetra Pak is a tube-formed straw, with only one outer seam, while the commercial one is a winded straw, with several outer seams as seen in Figure 1.

Figure 1. Tetra Pak tube-formed straw (A) and Commercial winded straw (B)



Paper straw samples were objectively evaluated for their mechanical and chemical properties related to mouthfeel through instrumental measurements, including water absorption (using an alternative Cobb Test), surface roughness (using a stylus profilometer), dry/wet compressive strength (using a universal tensile/compression tester) and tactile friction (using ForceBoard™). Furthermore, the mouthfeel perceptions were subjectively evaluated through sensory evaluation using 50 untrained Tetra Pak employees. They were asked to rate the intensity, from 0 to 10, to assess the mouthfeel attributes of paper straws, including roughness, stickiness, dryness, sturdiness, sogginess, and overall liking. Ultimately, the relationships between subjective and objective measurements were identified using Pearson's correlation approach at 90% and 95% confidence.

Results and Discussions

Instrumental measurements

Coating paper straws has proven to be an effective method in reducing water absorption, as the highest value was observed in the uncoated sample (R). However, the water absorption rate is also fluenced by the selection of coating material, with coating that exhibits higher hydrophobicity tends to be more efficient in decreasing water absorption.

Surface roughness is another critical factor that is believed to have a major impact on the mouthfeel. Consumers generally prefer

paper straws with smooth surface since it is similar to traditional plastic straws that they are used to. The study found that uncoated paper straws (R) exhibited the highest surface roughness, while the CM had the lowest surface roughness. As expected, uncoated paper straws are rougher than coated ones.

The study also found a considerable difference in compressive strength between dry and wet paper straws, with wet strength being significantly lower than dry strength in all specimens. This might be because moisture weakens the structure of the cellulose fibers, making them more susceptible to compressive forces. The application and type of coating materials may also influence the wet strength of paper straws. The coating material will act as a hydrophobic layer, which will not allow water to penetrate paper fibers and compromise their structural integrity (Montibon, 2010; Zawawi et al., 2013). However, it is also worth noting that the differences in seaming orientation or structural design of paper straws might affect their strength as well.

In terms of tactile friction, the study revealed that the coefficient of friction (COF) was higher in the coated paper straws when compared to the uncoated one. Moreover, the COF was found to be affected by the load applied during the measurements. A lower applied load at 1N displayed a higher COF value across all specimens.

Subjective measurement

The sensory evaluation revealed that paper straw variants differ significantly regarding their mouthfeel attributes and overall liking. Compared to uncoated paper straws, the coated ones showed a lower intensity in perceived roughness, stickiness, dryness, and sogginess, while demonstrating a higher intensity in perceived sturdiness. According to the spider plot in Figure 2, the sensory profile of paper straws is clearly divided into two groups, as evidenced by the two distinct hexagons. The SC and R specimens performed worse than the others, receiving the lowest overall liking scores, while the CM and W12C specimens were the most favored as they exhibited similar good performance across all attributes.

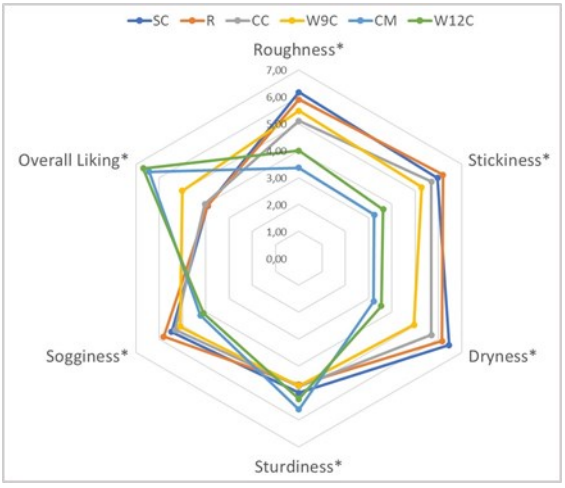


Figure 2. Spider plot showing the sensory profile of mouthfeel on paper straws. Asterisks (*) indicate a significant difference between each variant in that attribute (p-value < 0.05)

Correlation analysis

The sensory - sensory comparison results indicated that perceived roughness, stickiness, and dryness were directly related to each other, where panelists often evaluate perceived stickiness concurrently with perceived dryness. The reason behind this is that panelists interpreted the dryness of paper straw as it is absorbing moisture from their lips, and consequently turns to the sticky feeling. However, perceived sturdiness and sogginess were not strongly correlated with any other mouthfeel attributes. In terms of overall liking, panelists preferred paper straws that is less rough, dry, sticky, and soggy, but high in sturdiness.

The result of sensory - instrumental comparison presented in Table 1 highlights that tactile friction and water absorption exhibited the most promising instrumental measurements for predicting the mouthfeel percept-

-ions of paper straws. This was evident by their significant and strong correlations with most of the mouthfeel attributes and overall liking. Additionally, strong trends of correlation were also observed between the remaining three properties and some mouthfeel attributes but no statistical proof. The significance of these correlations may need to be confirmed with a more diverse range of variants.

Table 1. Pearson's correlation coefficient (r) values between mouthfeel sensory attribute and instrumental measurement of mechanical and chemical properties of six variants of paper straws

	Mouthfeel Attributes					Overall liking
	Roughness	Stickiness	Dryness	Sturdiness	Sogginess	
Water absorption	0.756*	0.886**	0.908**	-0.648	0.919**	-0.954**
R_a	0.781*	0.648	0.620	-0.663	0.595	-0.485
COF all data (1N)	-0.916**	-0.956**	-0.956**	0.861**	-0.896**	0.920**
Dry compressive strength	-0.222	-0.137	0.002	0.516	-0.066	-0.073
Wet compressive strength	-0.385	-0.491	-0.500	0.210	-0.617	0.622

*Note: The results presented in the number of Pearson's correlation coefficient (r) values (n=6). The asterisks * and ** indicate the r values that are significantly correlated at 90% confidence (p-value < 0.1) and 95% confidence (p-value < 0.05), respectively.*

It is worth highlighting that this study only examined a small number of variants based on the samples available in the company. This could potentially affect the statistical power of the analyses. To provide a more accurate and comprehensive assessment of the significant relationships, future studies should consider expanding the number of variants with a broader range of properties while maintaining control variables to be the same in every sample.

Conclusion

The application of coating material on paper straws effectively reduces water absorption and surface roughness; however, it leads to an increase in the coefficient of friction. Regarding compressive strength, wet paper straws exhibited significantly lower strength than dry paper straws across all variants. Through subjective sensory evaluation, coated paper straws were perceived as less rough, sticky, dry, and soggy, while demonstrating higher sturdiness. Several correlations were found between subjective perceptions and objective properties, with tactile friction and water absorption appearing to be the most potential in predicting mouthfeel of paper straws. Other properties only showed a trend of correlations with subjective perceptions without statistical proof. However, further research with a broader range of paper straw variants is recommended to confirm the statistical significance of these relationships.

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Hydrocolloid interaction with extruded materials in processed plant-based food products

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Introduction

The world population will reach 9.7 billion by the end of 2050 making it challenging to combat climate-related issues and meet the protein requirements of the consumers (United Nations, 2022). Meat is a great source of protein; however, it is considered as a carbon expensive product as compared to crops grown as a source of food energy. (Graham & Abrahamse, 2017).

Pulse protein fractions are used to produce Low Moisture (LM) extruded products, named Texturized Vegetable Protein (TVP) that gives fibrous texture similar to meat (Boye, Zare, & Pletch, 2010). Protein isolate and protein concentrate from pulse protein fractions are produced using wet and dry fractionation method, respectively, used in the development of plant-based burgers due to their attractive functional properties, high protein content, and consumer acceptability (Shanthakumar et al., 2022). Hydrocolloids, such as Methylcellulose (MC) are utilised in combination with TVP to improve the texture and water/oil binding properties in plant-based food products (Katy Askew, 2022).

In Norway, more preference is shifting towards using chemical free hydrocolloids having functionality similar to Methylcellulose (MC). Replacing Methylcellulose (MC) is a challenging task, as the functional qualities it gives are necessary for upholding the springy, meat-like texture consumers demand from their meat alternatives ("Replacing Methylcellulose Is Now Possible in Meat Alternative Applications," 2022). To replace Methylcellulose (MC), it is crucial to understand the properties of other natural

and chemical-free hydrocolloids in terms of texture, holding capacity, color, and rheological properties.

For this study, 9 hydrocolloids were studied based on their market availability and their wide usage in plant-based applications. Laccase was used in combination with Sugar Beet Pectin as according to Sakai, Sato, Okada, and Yamaguchi (2022), it catalyzes protein crosslinking and provide a textural characteristic similar to Methylcellulose.

Research objectives

1. Search for an alternative solution to Methylcellulose (MC).
2. Develop emulsions and study the interaction and potential use of ingredients (pulse protein fractions, pulse starch, and $CaCl_2$) with hydrocolloids and enzymes.
3. Evaluate quality parameters of ingredients and processed-plant-based food products in terms of rheological properties, texture, Water Holding Capacity (WHC), and color.

Methodology

Suspensions with 9 hydrocolloids (at 1 & 2%) were prepared to study the influence of $CaCl_2$ on hydrocolloids. Emulsions were further prepared to compare the difference between use of Pea Protein Isolate (PPI) and Pea Protein Concentrate (PPC) along with other ingredients, such as hydrocolloids, enzymes, pulse starch, $CaCl_2$, oil, and salt. Raw plant-based burgers were prepared using Texturized Pea Protein (TPP) in combination with emulsion (with PPI). The raw and cooked plant-based burgers were characterized in terms of viscoelastic property, texture, physicochemical properties, and color. The results highlighted here are most interesting/relevent for the industry.

Results and discussions

Suspension & Emulsion Characterization

$CaCl_2$ addition in suspensions significantly increased the G' for Alginate (AG) and decreased G' for Guar Gum (GG), Gellan Gum (GZ), Sugar Beet Pectin + Laccase (SBL), Xanthan + Gellan Gum (XG), and Xanthan Gum (XN). No impact on Kappa Carrageenan (KPG), Methylcellulose (MC), Sugar Beet Pectin (SBP), and Citrus Peel Pectin (CPP) is found.

All hydrocolloids were used to develop emulsions except for Xanthan + Gellan (XG) at 1 & 2% as it formed weak gels with $CaCl_2$. PPI addition significantly increased G' of all emulsions as compared to PPC. This is because PPI consists of denatured proteins that have higher hydrophobic interactions as compared to native proteins. From PPI and PPC emulsion characterization, it is concluded that Sugar Beet Pectin + Laccase (SBP) and Citrus Peel Pectin (CPP) can potentially substitute Methylcellulose (MC) at 2%.

Emulsion with PPI were used to develop plant-based burgers as addition of PPI contributes towards developing stronger protein-protein networks and high elastic properties (Vatansever, C. Tulbek, & N. Riaz, 2020).

Raw Batter Characterization

Raw batter samples were prepared by adding Texturized Pea Protein (TPP) to emulsion (with PPI) as shown in fig.1.

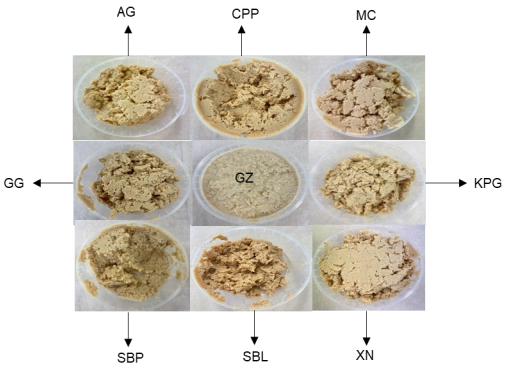

Fig. 1 Plant-based burger batter samples

Firmness (g) of raw batter samples were measured as shown in fig.2. Commercially, firmness (g) shows batter resistance to deformation and overall shaping and molding stability of the batter.

Citrus Peel Pectin (CPP), Alginate (AG), Sugar Beet Pectin (SBP), Sugar Beet Pectin + Laccase (SBL) have higher or similar firmness to Methylcellulose (MC) at 2%.

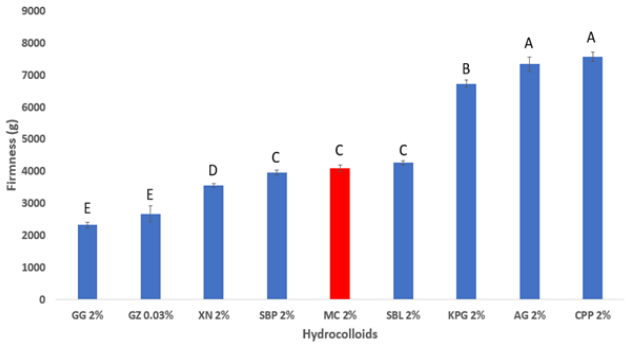

Fig. 2 Firmness (g) of raw batter

Cooked Burger Characterization

The hardness (g) of cooked burger samples were analysed as shown in fig.3. Hardness (g) describes the product's mechanical resistance from the force the molar teeth apply to compress food. From industrial point of view, it shows the stability of cooked burgers during transportation and storage.

Citrus Peel Pectin (CPP) has the potential to substitute Methylcellulose (MC) in terms of hardness (g) and chewiness. However, all the other hydrocolloids have hardness (g) similar to commercial burger samples (C-1, C-2, C-3, and C-4) at 2%. From the results, it is concluded that burgers developed in comparison to commercial burgers gives the same hardness level with less number of ingredients.

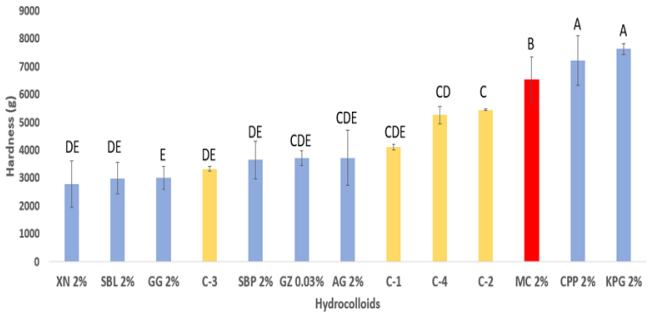

Fig. 3 Hardness (g) of cooked burgers

Holding Capacity (HC) % of cooked burgers is measured to analyse the ability of hydrocolloids to hold all parts of its water and oil under mechanical stress. According to results in fig. 4, heat treatment significantly improved the holding capacity of the burgers as almost all the samples had the same holding capacity % except for Sugar Beet Pectin + Laccase (SBL) which has the lowest holding capacity value. It is because of starch gelatinization in which starch and water are exposed to heat which ultimately causes the starch granules to swell. This results in absorption of water in an irreversible manner, giving a viscous and transparent texture (Rodriguez-Velazquez, 2017). Also, some hydrocolloids show better water and oil holding capacity when they are exposed to a high temperature.

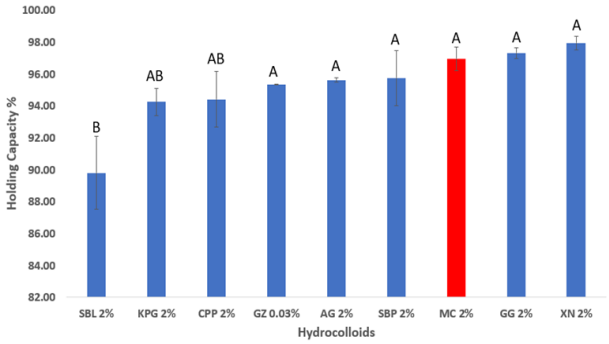

Fig. 4 Water/Oil Holding Capacity (%) of cooked burgers

Conclusion

The results from experimentations conducted were interpreted in terms of burger shaping/ molding stability, thermal stress, storage & transportation stability, and consumer chewing experience and a conclusion is drawn in comparison to the reference sample i.e., Methylcellulose (MC).

Alginate (AG) and Citrus Peel Pectin (CPP) have the potential to replace Methylcellulose (MC) in plant-based food products as they both improve the consistency of burger batters which allows an easier shaping or molding and a stable product . It further allows retaining its form during storage and transportation, whereas, Citrus Peel Pectin can additionally give chewing experience to consumers, storage & transportation stability, and shaping/molding stability.

Sugar Beet Pectin (SBP) and Sugar Beet Pectin + Laccase (SBL) also showed good molding/ shaping stability. Gellan Gum (GZ) and Guar Gum (GG) showed ability to bear thermal stress during cooking, whereas, good transportation and storage stability is shown by Sugar Beet Pectin (SBP), Xanthan Gum (XN), and Guar Gum (GG) as compared to Methylcellulose (MC). Kappa Carrageenan (KPG) and Citrus Peel Pectin (CPP) have the highest chewiness level and it could be used for improving the consumer chewing experience.

All the hydrocolloids have some strengths and weaknesses in comparison to Methylcellulose (MC). It solely depends on the plant-based burger manufacturer what kind of attributes they want in their final product for the consumer.

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Study on a rational combination of germination, milling, and fermentation improving the sanitary, technological, and sensory qualities of legume-based foods

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Master Thesis tutors:
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Introduction

The digestibility of lentils is significantly limited due to anti-nutritional factors (ANFs) *(Garrido-Galand et al., 2021)* and protein compact structure. Due to the unfavorable organoleptic properties, its acceptability in the market is also limited. The research aims to study the hydrolytic enzymes present in the seeds or produced during germination in terms of optimal conditions of their activities (pH, temperature). Then activate them in a controlled manner (conditions and duration) to produce fermentable substrates to improve the final products' microbial colonization and organoleptic properties. Simple sugars like glucose and maltose derived from starch can be assimilated by selected lactic bacteria to improve sanitary conditions by acidification. The ability of lactic bacteria and yeasts to catabolize amino acids to aromatic compounds (acids, alcohols, and esters) will be also evaluated. This processing technique can reduce the anti-nutritional factors and improve organoleptic properties.

Research objectives

- Design protocols concerning germinated and non-germinated lentil flour production, enzymatic assay, and fermentation.
- Compare the enzymatic activity of germinated and non-germinated lentil flour.
- Design the microorganism consortium for fermentation of germinated lentil flour.

Methodology

1. Germination of lentil seeds: To optimize the water requirement for effective germination of lentils, 27 lentil seeds were soaked for 24h, and the water absorbed by the lentil seeds after 30min, 1h, 2h, 3h, 4h, 5h, 6h, 7h, 24h were calculated to determine the Phase II of seed germination to ensure enzyme production. Germination of the lentil seeds was done for 24h at 20-25 ˚C followed by drying for 24h at 20-25˚C to make the seed ready for milling. 130 gm of water per 100gm seeds were used for germination.
2. Flour production: To obtain the flour the germinated and non-germinated lentil seeds were passed through the milling equipment four times and stored at 4˚C.
3. α-Galactosidase assay: 20 Protein extracts were extracted from germinated and non-germinated lentil seeds respectively at pH 4-6.9 and with and without the addition of PVPP. The reaction of α-galactosidase was conducted using protein extract as the enzyme and 4-Nitrophenyl -D-glucopyranoside (PNPG) as substrate at 35˚C and pH 6.

4. Selective agar analysis of lentil flour for *Bacillus Cereus*: The non-germinated diluted flour sample was renumerated on PCA. The grown strains were further inoculated onto *Bacillus cereus* Agar (Mossel).
5. API Gallerie study of microbial strains selected for fermentation: The strains *Lactobacillus delbrueckii* (CNRZ 207), *Lactobacillus delbrueckii* (CNRZ 225), *Lactobacillus delbrueckii ssp. bulgaricus* (ATCC11842), *Lactobacillus delbrueckii ssp. bulgaricus* (CNRZ 397), *Lactobacillus acidophilus* (146), *Streptococcus thermophilus* (LMD9), and *Lactobacillus delbrueckii* (CNRZ 226) were sourced from the INRAe collection. The strains' fermentation potential was then analyzed using API 50 CHL Medium for 50 sugars.

Results and Discussion

As the seeds enter Phase II of germination, the water absorption rate decreases significantly, and the radicle elongation is observed. It was observed that within 24h the seed was able to attain Phase II followed by the elongation of the radicle ensuring the production of hydrolytic enzymes. The optimum water requirement for germination was found to be 130 ml water per 100 g of lentil seed.

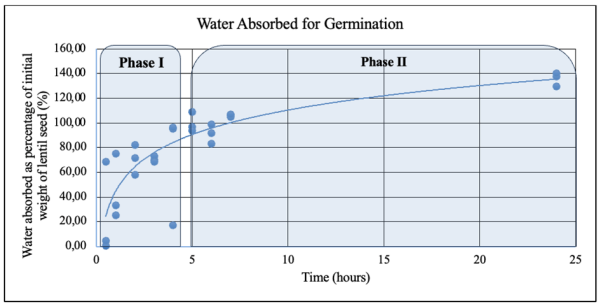

Figure 1. Graphical representation of the water absorbed by the seeds with respect to time.

To optimize the enzymatic activity, proteins were extracted from the lentil flour at pH 4-6.9 and PVPP was used during the extraction process for the removal of polyphenols. In the case of the germinated lentil flour, the α--galactosidase activity observed in the protein extracts with PVPP was found to be significantly higher ($p<0.05$) compared to the extracts in the absence of PVPP (Fig 18). Whereas no such significant difference was observed in the case of the non-germinated lentil flour. *Rohn, Rawel, and Kroll (2002)'s* study on protein and polyphenol interaction states that phenolic compounds are oxidized in the presence of endogenous polyphenol oxidase to produce quinones. Quinone is a reactive substance capable of interacting with free amino acid groups of protein. This reaction of oxidized phenolic compounds with the side chains of the enzyme leads to changes in the enzyme's electrophoretical behavior, solubility, molecular weight, hydrophobicity, secondary and tertiary structure, as well as thermodynamic parameters.

The presence of p-hydroxybenzoic (29.3 µg/g), chlorogenic (155.7-213.2 µg), and gallic acid (90.9-136.8 µg/g) in lentils was confirmed by the study of *Xu and Chang (2010).* The reaction of α-galactosidase was carried

out at 37˚C and pH 6. Since the medium was was not alkaline, polyphenol oxidase could be responsible for the oxidation of phenolic compounds and the production of quinones in our samples. *Sikora et al. (2019)* extracted and studied the polyphenol oxidase from ready-to-eat lentil sprouts. The optimum pH and temperature of the enzyme were found to be pH 4.5-5.5 and 35˚C and was also found to be active at pH 6 and 37˚C which overlaps with the parameters of the α-galactosidase activity experiment.

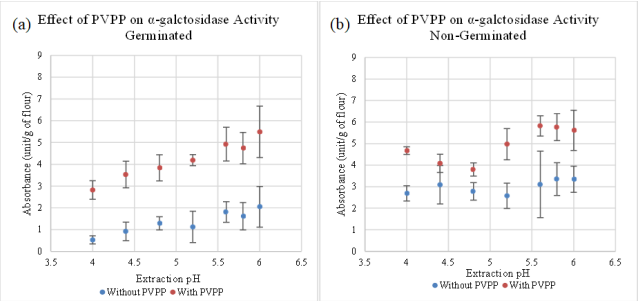

Figure 2. Graph showing the comparison of α-galactosidase activity (a) Without PVPP vs With PVPP (Germinated lentil flour) (b) Without PVPP vs With PVPP (Non-germinated lentil flour).

The parameters for α-Amylase assay with HPLC were also designed to characterize the type and quantity of sugars produced by the enzyme to predict the fermentation model. It was observed that the enzyme produced both glucose and maltose, but the concentration of maltose produced was higher than the glucose one. Further experimentation with the lentil flour was not possible in the time frame of the internship. The experimentation with flour will help to optimize the sugar produced for effective fermentation.

The API 50 CHL Medium was used to characterize each LAB strain's capacity to metabolize the carbohydrates potentially present in the lentil flour: starch, maltose, and glucose. After the hydrolysis step and the thermal treatment, the flour is expected to contain mainly starch, but also maltose and to a lesser extent glucose. The quantity of maltose and glucose will be generated during a “brewing” step (activation of the enzymes of the germinated flour by hydration and temperature). This step will be added in the next steps of the project.

Table 1. Results obtained from API Gallerie 50 analysis of microbial strains sourced from INRAe. (Green means the bacteria is able to use the sugar as a substrate).

Strains		Substrate				
		D-Glucose	D-Maltose	D-Raffinose	D-Saccharose	D-Lactose
Lactobacillus delbrueckii	*NRZ 207*					
Lactobacillus delbrueckii	*CNRZ 225*					
Lactobacillus delbrueckii	*CNRZ 226*					
Lactobacillus delbrueckii ssp. bulgaricus	*ATCC11842*					
Lactobacillus delbrueckii ssp. bulgaricus	*CNRZ 397*					
Lactobacillus acidophilus	*146*					
Streptococcus thermophilus	*LMD9*					

Conclusion

It was evident that the use of PVPP significantly impacted the protein extract color, protein content, and enzymatic activity. It can be concluded that polyphenols could have a negative impact on enzyme activity and further characterization of phenolic compounds in the protein extract is required to confirm it. The hypothesis of how polyphenols interact with the enzymes could also apply to amylases and proteases. Maximum activity of polyphenol oxidase was observed after 24h germination on mung beans *(Tajoddin, Manohar, and Lalitha, 2013)*. To confirm the hypothesis polyphenol oxidase enzyme activity of the protein extract obtained from germinated and non-germinated lentils is required to be characterized and compared. After decortication, cooking, and soaking, lentils' phenolic content decreased by 80%, 16-41%, and 22-42%, respectively *(Singh et al., 2017)*. Decortication prior to milling can be done to reduce the phenolic compound in the protein extract.

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Improving R&D practices: Development of a sensory lexicon for bakery products and its validation for egg-replaced brioches and buns

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Introduction

The COVID-19 pandemic and the Russian-Ukraine war led to many food behavior changes. In France, 56.2% of the population changed their diet, with 41% following a healthier one, and 18.8% identifying as flexitarians(Skotnicka *et al.*, 2021; Statista, 2022). Additionally, inflation increased 8.4% in 2022, and egg production fell by 8% (Arce *et al.*, 2023; Reuters, 2022). This prompted food companies to change their recipes to meet the demand.

Microalgae are microrganisms with many advantages and nutrients (like proteins and polyunsaturated fatty acids). They exert antioxidant, immunomodulatory, anticarcinogenic, among other activities (Matos *et al.,* 2017). For that and many other reasons, they are used in food, but they face challenges, especially due to their intense color and strong flavor (Yazici & Ozer, 2021) .

Algama Foods, a company in Paris, uses them in bakery products as egg-replacers to create healthier alternatives. To ensure that, standardized sensory practices must be proposed, such as to create a well thought-out lexicon and to use appropriate methodologies to determine that no significant differences are found between products with and without egg.

Research objectives

A standardization of a sensory vocabulary have not yet been established in Algama Foods. The study intends to understand their products and develop a sensory lexicon. It will also put it to test in two

products: brioches and buns, where different formulations with an egg-replacer will be evaluated.

In order to do so, the following objectives must be followed:

- Internal product information will be revised
- A bibliography research will be conducted
- A lexicon and a sensory wheel will be generated
- A consumer-centric sensory approach will be proposed for the evaluation of brioche and bun with different egg-replaced formulations
- Statistical analysis will be performed to draw conclusions

Methodology

Lexicon development

A research in literature approach was followed by searching published works, from 1980's to 2023, on Google Scholar and PubMed. The keywords used were "sensory lexicon", "sensory lexicon cakes", "sensory lexicon biscuits", "sensory lexicon viennoiserie" and "sensory lexicon creams".

The retrieved attributes were further classified by appearance, texture, odor, flavor and aftertaste. A subsequent grouping of similar attributes was conducted to narrow down the lexicon. A translation to French, to meet the requirements of the company, was done with the help of the online tools DeepL and WordReference.

A first batch of appearance and texture "primary attributes", chosen by their relevance to the company, were aligned on a qualitative session with 10 panelists of all genders and between 24—34 years old. They were also trained on their use.

A sensory wheel of those primary attributes was generated using Microsoft Excel.

Egg-replacement in brioche and bun

To determine the feasibility of the use of Tamalga® (TAM), a feasibility test was performed for both, the brioches and the buns, with three different concentrations (50% TAM, 75% TAM and 100% TAM).

After those, two further evaluations were done for brioches (Evaluations A and B) and one for buns (Evaluation C). Evaluation A consisted on a Control and three different confidential formulations with different concentrations and dilutions. Evaluation B included a Control and three additional formulations. Evaluation C, the same but for buns (*Table 1*).

Table 1. Products for sensory evaluation.

Feasibility tests			
Brioche*		**Bun**	
CR1	Control (100% Egg)	CB1	Control (100% Egg)
FR1	50% TAM + 50%	FB1	50% TAM + 50%
FR2	75% TAM + 25%	FB2	75% TAM + 25%
FR3	100% TAM	FB3	100% TAM
Evaluation A*			
CR2	Control (100% Egg)	-	-
TR1	Proposal 1 (brioche)	-	-
TR2	Proposal 2 (brioche)	-	-
TR3	Proposal 3 (brioche)	-	-
Evaluation B*			
CR3	Control (100% Egg)	-	-
TR4	Proposal 4 (brioche)	-	-
TR5	Proposal 5 (brioche)	-	-
TR6	Proposal 6 (brioche)	-	-

Evaluation C			
-	-	CB2	Control (100% Egg)
-	-	TB1	Proposal 1 (bun)
-	-	TB2	Proposal 2 (bun)
-	-	TB3	Proposal 3 (bun)

A Quantitative Descriptive Analysis (QDA) was followed for all evaluations, where the brightness, softness, stringy crumb, first bite, sweetness and vegetal notes were evaluated on a 10-point intensity scale in sequential monadic. Ten panelists of all genders, between 24—34 years old tasted the products and Xlstat was used to perform One-Way ANOVAs + Tukey Test at 95% confidence level, as well as Principal Component Analysis (PCA) and Cluster Analysis.

Results and discussions

Lexicon Development

954 attributes were obtained and narrowed down to 175, an 81.6% optimization. Additionally, 26 primary attributes were selected (*Figure 1*).

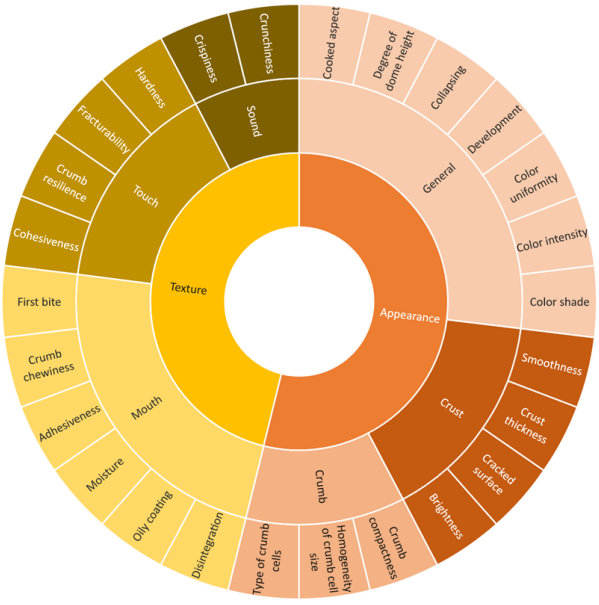

Figure 1. Sensory wheel for primary attributes.

Attributes must be general enough to apply to a wide variety of products within the same categories and should allow panelists to use them to describe differences (Chambers *et al.*, 2016; Krasner, 1995: Ickes *et al.*, 2017).

As a communication tool, language is important. Words function within the limits of common sensory experience and environment (Zanoni, 1996). Globalization of markets made essential to use appropriate descriptive terminology. Translations must be well thought-out (Vázquez-Araujo *et al.*, 2011).

Egg-replacement in brioche and bun

Products evaluated in Evaluation A and Evaluation C (*Figure 2*) were found with significant differences after performing an ANOVA and Tukey test at a 95% confidence level. The main observations were in brightness between the control CR2 and the proposal TR2 for the brioches, with the latter being brighter, and in softness between the control CB2 and the proposal TB3 for the buns, with the reformulation being less soft.

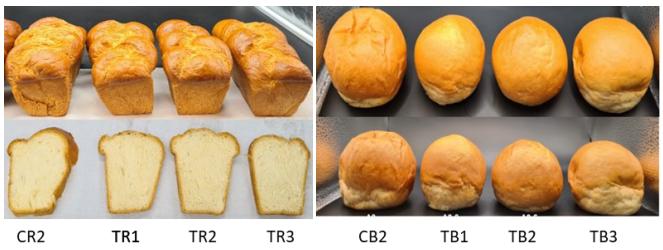

Figure 2. Evaluation A (brioches) and C (buns).

Eggs are essential to obtain the desired volume, texture and color, and it's been observed these are impacted when replacing them (Ratnayake *et al.*, 2011; Geera *et al.*, 2011). When using microalgae many properties are preserved, with reduced volume and porosity being the most affected the higher the concentration (Kafyra *et al.*, 2018; Barzegar *et al.*, 2021).

Limited foaming activity could reduce the porosity, impacting the texture, such as reduced softness for TB3 (Kafyra *et al.*, 2018). Color and brightness, usually provided by the egg yolk, is important for consumers (Csurka *et al.*, 2021). These are also a response to the Maillard reaction and the caramelization, which are impacted by the water absorption and amount of water present in the product (Hedayati *et al.*, 2022). This could be the reason why the brioche TR2 is brighter.

Two classes for brioches (*Figure 3*), where all reformulations except for TR1, TR2 and TR3 coexist in the same sensory space as the Control. Four classes obtained for the buns (*Figure 4*), with product TB2 in the same cluster of the Controls.

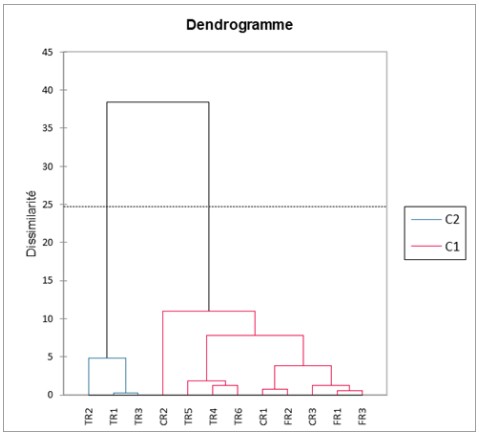

Figure 3. Classes obtained (brioches).

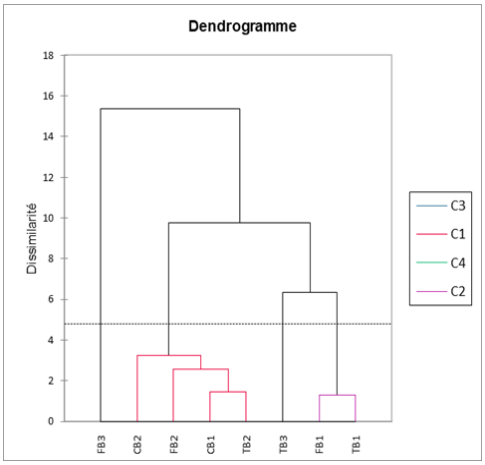

Figure 4. Classes obtained (buns).

Conclusions

The sensory lexicon works as a "living document" that will be used as a communication tool within Algama Foods and with their partners. Sensory analysis, as a whole, has proven to be crucial for future product development.

Based on the results of this study, it can be said that Tamalga® can be used as an egg-replacer for brioches and buns with minor impact in texture and appearance. Reformulations TR4, TR5 and TR6 for the brioches, and the TB2 in buns are the most promising and similar to the non egg-replaced products.

If further understanding on the impact of this change wants to be understood, a consumer test with heavy consumers could be conducted. The proposal is to work with the most feasible altertative(s) that have shown a better performance and evaluate them against the control in sequential monadic, with a forced preference at the end. On the other hand, a trained panel could be employed to get a better picture on the sensory space of the current Control. By evaluating the products with the methodology of a Degree of Difference we could understand if the products do indeed fall within the natural space that has been created by the actual formula.

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Enhance the functionality of egg yolk used in Häagen Dazs ice cream base

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Ice cream is a complex system made of ice crystals, air bubbles, fat, and sugar in a continuous aqueous phase. This microstructure is crucial for sensory qualities and consumer acceptability. Emulsifiers, like egg yolk, play a key role in displacing milk proteins on the fat globules, promoting fat partial coalescence and forming fat network during freezing. The latter impacts the physical properties of ice cream such as melting resistance and stability, and sensorial parameters such as creaminess and mouthfeel.

The objective of this master thesis is to deepen the understanding of the specific functionality of egg yolks in Häagen Dazs ice cream focusing on viscosity and emulsification properties and subsequently enhance the functionality of egg yolks by the means of enzymatic treatment, acidification, and high shear mixing.

CONFIDENTIAL TOPIC

Exploring hybrid concepts: pea and dairy protein mixtures

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Introduction

The plant proteins industry is rapidly growing in recent years as a result of many factors, such as the health benefits, the increased awareness of food security, and the demand for more sustainable and environmentally friendly food sources (Hertzler et al., 2020).

Until plant-based proteins gained popularity, human nutrition was heavily based on milk proteins that play a key role in human nutrition as they are a rich source of essential amino acids, vitamins, and minerals. Casein and whey are highly bioavailable, meaning that they are easily absorbed and utilized by the human body, making them a vital component of a balanced diet (Day, Cakebread and Loveday, 2022).

The Adult Nutrition market has experienced a growing interest in products that focus on promoting healthy aging and enhancing physical performance, with protein as the essential nutrient due to its role in building and maintaining muscle mass. Products that are relatively high in protein content are therefore in demand, and the quality of the protein is also important, with PDCAAS being a commonly used value to evaluate the protein quality (Schaafsma, 2012).

Considering these aspects, the development of a hybrid ready-to-drink (RTD) beverage that combines plant and dairy proteins can result in a product with several benefits from the consumer's perspective, such as an improved nutritional profile, and better sensory attributes like flavors and textures.

Research objectives

In this project, the aim was to develop a hybrid RTD that meets the nutritional needs of consumers while also having appropriate sensory and physicochemical properties. For this reason, the following objectives were set:

- To investigate the behavior of mixed proteins, specifically pea and dairy, in a solution.
- To evaluate the processing parameters that can contribute to the development of a high-quality hybrid RTD.
- To develop a prototype RTD that meets the desired criteria in terms of nutritional, sensory, and physicochemical characteristics.
- To identify the potential benefits of hybrid RTD products, specifically with regards to nutritional and functional advantages.
- To propose packaging and labeling of the final product while considering the factors that may affect the hybrid matrix.

Methodology

First part: Preparation and evaluation of the mixed protein formulas

For all the trials that took place during this project, pea protein isolate (PPI), sodium caseinate (NaCas), whey protein aggregates (WPA), and micellar casein isolate (MCI) were used. For the first trial, the protein content chosen was 12%. The samples are presented in Table 1.

Table 1. Protein solutions for the trial with 12% total protein.

Total Protein 12%	
Solution	**Ratio**
PPI	100
NaCas	100
WPA	100
PPI:NaCas	80:20
PPI:WPA	80:20
PPI:NaCas:WPA	60:20:20
PPI:NaCas: WPA	50:25:25
PPI:NaCas:WPA	60:30:10
PPI:NaCas:WPA	60:10:30

For the second trial, it was decided to go further with the formula containing pea protein isolate, sodium caseinate, and whey protein aggregates with a total protein content of 14% and examine the behavior of the samples containing different ratios of these proteins. The samples are presented in Table 2.

Table 2. Protein solutions for the trial with 14% total protein.

Total Protein 14%	
Solution	**Ratio**
PPI	100
PPI:NaCas:WPA	60:2,5:37,5
	60:05:35
	60:7,5:32,5
	60:10:30
	70:15:15

An overview of the processing steps is seen in Figure 1. The samples were measured according to the following parameters: visual assessment, color, pH, viscosity, particle size distribution, and optical microstructure. For some of the unstable formulas, SDS-PAGE analysis was also performed to investigate which protein fractions were responsible for the instability. All the analyses were performed after homogenization, after retort, after 2 and 4 weeks of storage at 4°C and 20°C.

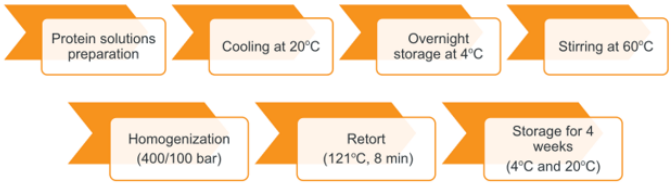

Figure 1. Processing steps for the mixed-protein samples preparation.

Second part: Development of the hybrid RTD beverage

The RTD development followed almost the same protocol as for the protein solutions. While the sample was being stirred at 60°C, the sweeteners were added, followed by the addition of fat that was incorporated in the mixture with the aid of Ultraturrax. The thermal process that was used after the homogenization step, was UHT with downstream homogenization at 121°C for 8 minutes. The produced RTD was analyzed physiochemically as the previous samples. Furthermore, the Protein Digestibility-Corrected Amino Acid Score (PDCAAS) was calculated and the sensorial, packaging and labelling parameters were examined.

Results & Discussion

Mixed protein formulas

The findings from the trial with 12% total protein content confirmed that the combination of PPI, NaCas, and WPA in specific ratios can result in relatively small protein aggregates and low viscosity values, which is a critical factor for the stability of protein-based RTDs. Therefore, it seemed valuable to further explore the optimal combination of these proteins in different ratios while increasing the total protein content towards 14%.

Despite the minor differences in composition among the various solutions in the trial with 14% total protein, only one sample made with PPI:NaCas:WPA in a ratio of 65:05:35 exhibited the desired properties necessary for further development as a hybrid RTD. The average particle sizes D50 and the viscosity of the samples with 14% total protein are presented in Figure 2 and Table 3 respectively.

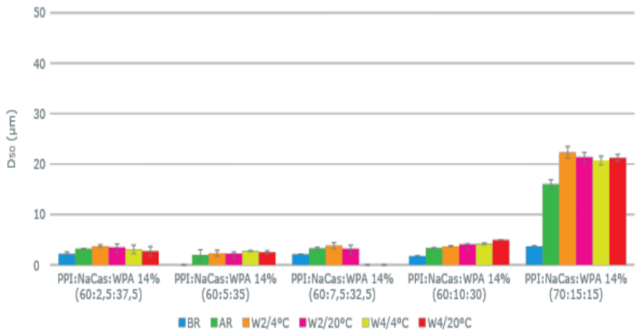

Figure 2. Average particle size of the samples from the trial with 14% total protein before retort (BR), after retort (AR) treatment and after storage at 4°C and 20°C for 2 and 4 weeks.

Table 3. Viscosity of the samples from the trial with 14% total protein before retort (BR), after retort (AR) treatment and after storage at 4°C and 20°C for 2 and 4 weeks.

Viscosity in shear rate 100/s (mPa*s)						
Sample Name	Before retort (BR)	After retort (AR)	2W/4°C	2W/20°C	4W/4°C	4W/20°C
PPI:NaCas:WPA 14% (60:2,5:37,5)	292.42	192.36	238.59	300.57	266.55	277.53
PPI:NaCas:WPA 14% (60:5:35)	-	33.864	42.107	49.156	51.62	-
PPI:NaCas:WPA 14% (60:7,5:32,5)	296.77	197.09	291.09	312.31	-	-
PPI:NaCas:WPA 14% (60:10:30)	303.4	137.47	183.48	183.24	194.9	218.59
PPI:NaCas:WPA 14% (70:15:15)	203.64	173.98	227.04	267.05	270.84	306.65

Hybrid RTD beverage

The selected protein blend used for developing the RTD showed a PDCAAS score of 1.12, which was truncated to 1. Therefore, it can be concluded that the mixed protein blend is a complete protein source that meets the amino acid requirements for human growth and development.

Regarding the sensory evaluation, the hybrid with 14% total protein, it was found to have between clear and major difference from the reference made with the same amount of pea protein. It was a common coming finding for all the participants that the taste was less beany. The aftertaste was evaluated as sweet with longer duration, milder with fewer pea notes, and milky.

Finally, combining all this information we know about protein blends, the idea is to use

a carton package designed for aseptic filling. The package will consist of paper to create stability and strength and aluminum foil that acts as an oxygen, light, and flavor barrier, needed in our case. To protect from external moisture, adhesion between the other materials, and effectively seal in the liquid contents, the other layers of the package will be composed of polyethylene (PE). The lid will be made of high-density polyethylene (HDPE). The proposed package is shown in Figure 3.

Figure 3. The proposed packaging for the hybrid RTD.

Conclusion

This project was aimed to the development of a hybrid RTD that meets the nutritional needs of consumers and has the suitable sensory and physicochemical properties.

Reaching 14% total protein by using only PPI is not feasible , thus making the addition of WPA and NaCas to stabilize the mixture really impactful.

It seems that the mixed blends of plant-based and dairy proteins are a combination, which gives several functional properties, such as emulsification, self-stability and homogeneity and at the same time it can lead to a formulation that has a high-quality protein source and improved sensorial properties. By incorporating plant-based protein, the final product will not only offer a most cost-effective alternative to dairy RTDs, but it will also appeal to consumers looking for flexitarian, more sustainable and less-animal derived options.

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Relationship between food shelf life and environmental impact of Tetra Pak packages

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Introduction

Tetra Brik Aseptic packages rely on aluminum foil for strong protection against moisture, gases, light, and microorganisms. However, the aluminum production contributes significantly to greenhouse gas emissions, accounting for one-third of Tetra Pak's base materials emissions and to around 20% of the Tetra Pak's value chain emissions . In pursuit of a greener future, Tetra Pak is on a mission to achieve net zero carbon emissions by 2030. To achieve this goal Tetra Pak is developing new barrier structures to replace aluminum. These innovative structures contain less aluminum and contribute to the fully renewable, paper-based packaging.

Research objectives

The aim of this study is to theoretically assess the feasibility of integrating new sustainable barrier materials into Tetra Brik Aseptic packaging structure by analyzing their environmental and barrier performance and to find a relationship between these parameters.

To achieve this aim, the following research objectives have been set:

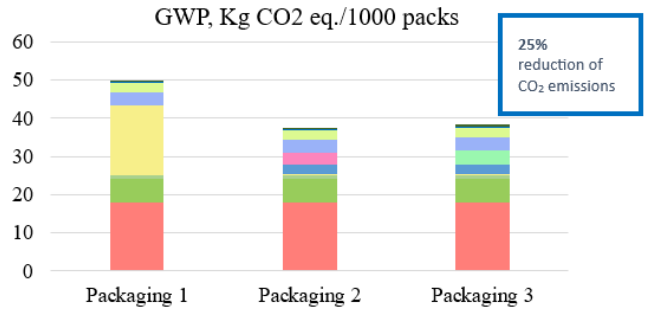
- to investigate the barrier properties of a new barrier material structures
- to assess the direct environmental impact, caused by the production of the new barrier material structures
- to analyze the efficiency of a new barrier materials by estimating a potential shelf-life length
- to estimate the potential indirect environmental impact associated with the barrier properties performance.

Methodology

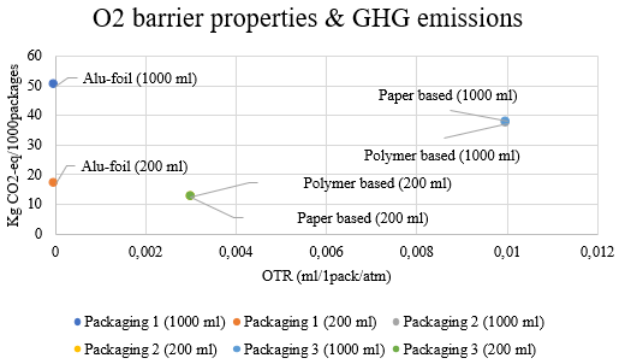
This study employs a holistic approach to assess the environmental impact of packaging structures with potential new barrier materials. To evaluate the direct environmental impact, a Life Cycle Analysis (LCA) using SimaPro software was peerformed. This comprehensive analysis assesses the environmental factors across various stages of the packaging life cycle, with the specific focus on greenhouse gas emissions. Additionally, the study examines the barrier properties of the packaging structures, specifically focusing on the oxygen transmission rate (OTR) and water vapor transmission rate (WVTR). The Norner calculator software is utilized to accurately measure and evaluate these barrier properties. Based on the examined barrier properties and Vitamin C degradation the shelf-life was estimated, which represents possible indirect environmental effect.

Results and discussion

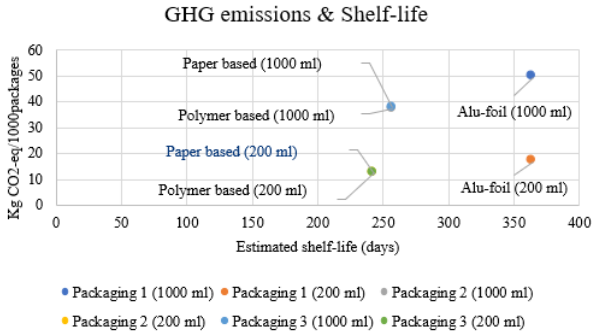
Results from Life Cycle Analysis demonstrated that production of raw materials for new barrier materials structures yields a beneficial result, lowering the CO_2 emissions of packaging by 25%.



Evaluating the results obtained by the barrier properties assessment and comparing them with the generated emissions revealed that higher values for barrier properties were associated with higher emissions. Aluminum foil performed best in terms of barrier properties but had the least desirable GHG emissions.



The relation between the greenhouse gas emissions generated during the production of packaging and its shelf-life length (based only on the Vitamin C degradation) demonstrated a linear correlation between GHG emissions and shelf-life, where increased emissions is associated with longer shelf-life due to the influence of barrier properties. Analysis of the graph reveals that both new sustainable structures have the same shelf-life length. However, comparing them with the current base structure the shelf-life length for both 1000 ml and 200 ml volumes decreases by 29% and 33%, respectively. Furthermore, the new sustainable structures result in a reduction of GHG emissions by 25%, and the estimated shelf-life decreases by approximately 30%. Therefore, the implementation of new sustainable materials has an equivalent effect on both direct and potential indirect environmental factors.



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Generating and Stabilizing Aerated Textures to Drive Product Innovation: Technical Pathways and Prototype Development

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Aerated products have gained popularity across different industries due to their excellent sensory attributes, such as lightness in the mouth, spreadability, quick release of active ingredients, and ease of application. As a result, numerous products in the market claim to have aerated textures, using terms like "mousse," "whipped," or "foam". However, a significant proportion of these products fail to deliver on the promised aerated aspect or lack the desired texture upon application. This indicates the necessity for innovation and development efforts to address the inherent instability associated with them.

This study aimed to create an aerated texture stable during storage and transportation. It involved an extensive analysis of existing literature and a development process. The research led to the identification of crucial product and process parameters and valuable insights into the complexity of foam production. The proposed technical solution holds great potential, contributing significantly to the advancement of product development of aerated products with enhanced stability.

CONFIDENTIAL TOPIC

Environmental tool evaluation and databased benchmarking of sustainable packaging materials for Micvac technology

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Introduction

Consumers are increasingly seeking healthy, convenient, and quick-to-prepare foods, making the selection of appropriate packaging materials complex. Packaging developers must ensure compatibility between the product and packaging materials, required shelf life, production line efficiency, cost, and environmental impacts. Microwave sterilization and pasteurization systems have gained attention in recent years for their effect on reducing adverse environmental impacts through efficient use of water and energy. Micvac AB is a solutions provider for in-pack pasteurisation of chilled ready meals with its technology consisting of in-pack cooking and pasteurization in a single continuous process.

This thesis project addressed the following research question: What is the most sustainable option in the materials market for Micvac packaging solution?

To answer this question, this project proposed the development of an evaluation tool for Micvac technology that incorporates various sustainability criteria to benchmark and evaluate the environmental performance of a company's primary packaging. The proposed evaluation tool considers different sustainability criteria which affect the environmental impact throughout the product-packaging life cycle.

Methodology

Firstly, a theoretical framework provides general information about packaging terminology and in-pack pasteurization tech-

-nology definitions. To answer the research question, literature research and semi-structured interviews were conducted. The literature review encompasses conventional packaging materials and innovative packaging solutions on microwave in-pack pasteurization technology for food applications. Additionally, EU legislative acts on packaging and packaging waste, ready meals market trends, trade organization policies on packaging materials and current design-for-recycling guidelines were scouted and analysed. This review assisted the preliminary selection of five solutions to be considered in the evaluation. Online interviews and email communications were conducted with relevant key actors in the investigated supply chain. The utilized environmental impact tool is further described on its origin and the development it went through during the course of this study to properly evaluate the selected solutions.

Results and discussion

The literature review saw numerous packaging solutions being generally divided into non-self-venting materials and self-venting materials. The selection of appropriate packaging materials must consider package thermal properties, gas barrier properties, mechanical properties, and food-package interactions. Active packaging systems have significantly changed the food production landscape due their properties and impact on reducing food waste, consequently reducing the environment impact.

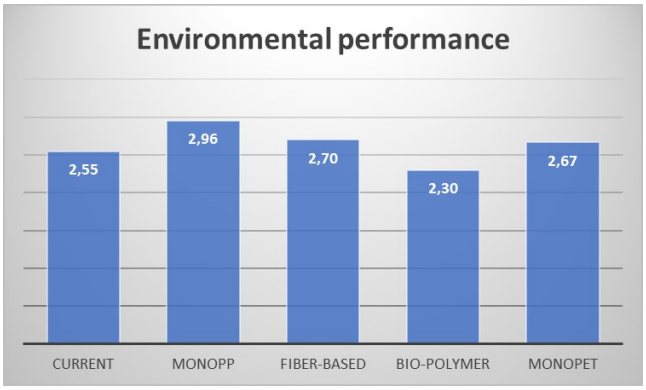
The analysed Micvac packaging is comprised of three components: the tray, the lid film and the valve. The five evaluated packaging solutions in this study are the following: the current Micvac packaging, monoPP, fiber-based, biopolymer, monoPET. The main differences between solutions are their trays material, whereas the film and the valve are different in two of the solutions.

The new EC proposal in November 2022 introduced new measures on the compulsory targets waste reduction for member states and it is expected that this proposal will be extended in a new regulation approving recycled content in packaging (other than PET) for food contant applications and possibly establishing mandatory quota of recycled content.

In the analysis of ready meals and ready meals packaging markets from the data gathered from Euromonitor International, a growth is noticed in all seven countries being investigated: Sweden, Norway, Finland, USA, France, UK, Spain. Many factors have influenced the shift of previous consumer perception regarding ready meals as unhealthy. Convenience, increasingly busy lives, nutrition and abundance of product varieties are some of the most common reasons which have pushed consumers to purchase more ready meals. It is forecasted that the growth will continue with noticeable differences between countries with the highest growth for ready meals and chilled ready meals foreseen in Finland and Spain.

The environmental tool utilizes a lifecycle approach, but it is less complicated than an LCA and requires less input from the packaging developer. The tool evaluates the environmental impact of a packaging system across four areas: packaging material, transport efficiency, influence on food waste, packaging end-of-life. Each assessment area includes several performance criteria, with five levels assigned to each criterion. The packaging solutions receive scores from 1 to 5 based on their properties where level 5 is the highest level, indicating the best performance. In the end an average of all these criteria is calculated based on the importance of each area which was determined on the previous studies and assumptions made during the study. The evaluations were done in a Swedish context.

MonoPP showed the overall highest performance, scoring an average of 2.96 out of 5. All the solutions have their strong performing areas and their weak ones, with the influence on food waste being highly in favor of the current packaging and monoPP due to the long-shelf life they provide to the product. As expected, in the packaging-end-of life area the fiber-based option performs the best due to high recycling rates of paper material in Sweden.



Results of the environmental tool evaluation for every packaging solution, 1.00 represents the worst environmental score and 5.00 the best environmental score.

The food manufacturers and retailers are also demanding monomaterial packaging and reduction of plastic content whenever possible without compromising the food safety and shelf life. Their environmental strategies include bold target goals such as reaching 100% recyclable packaging in this decade. These important actors in the supply chain are adjusting for the future legislative requirements of introducing recycled content in their packaging.

Conclusion and suggestions for further research

The results of this study showed that a mono material PP solution is the most sustainable solution for the Micvac technology at the moment. This solution aligns with the requirements of the food manufacturers and retailers interviewed during the research.

The proposed monoPP option conforms with the recent EU packaging proposal and would comply with the upcoming EU legislation regarding mandatory incorporation of recycled content in packaging for food contact. However, it is important to consider other solutions as well as they did not score significantly lower than the monoPP. Most of the investigated innovative packaging solutions in the literature review are multilaminate materials with low production volumes therefore it is expected that they would not perform optimally in the environmental tool due to difficulties in recycling packaging made of different materials and the lack of proper collection streams after they are disposed by the consumer.

For further research it is suggested to review the technological feasibility and the economic viability of implementing the specific packaging solutions mentioned in this study within Micvac technology. Sourcing availability and process efficiency can be deeply investigated. It is also interesting to include more actors in the supply chain, particularly the consumers whose behavior determines the fate of the packaging after consumption. Conducting sensorial tests of the proposed packaging solutions would provide valuable feedback on the acceptance of different sustainable packaging options regarding ready meals. Another interesting area of future research would be to investigate the application of the proposed evaluation tool in other packaging solutions of Micvac such as the thermoform.

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Unlocking deliciousness in pea protein through fermentation

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Introduction

Pea protein has gained significant attention as a sustainable alternative to animal-based proteins. The pea protein market is growing at a rapid pace, driven by increasing consumer awareness about the benefits of plant-based diets and a growing demand for sustainable protein sources (Grand View Research, 2022). The COVID-19 pandemic has also contributed to the growth of the pea protein market, as consumers have become more health-conscious and are looking for products that support a healthy lifestyle.

Despite the growing demand for pea protein, there are still several challenges that need to be addressed. The low solubility and undesirable aroma of pea protein have been major issues in the food industry, leading to lower demand for pea protein-based products (Schindler, 2012; Pontonio and Rizzello, 2021). To overcome these challenges, researchers are developing new processing techniques and flavor masking technologies to improve the sensory qualities of pea protein (Lan, 2019).

Anti-nutritional factors (ANFs) in pea protein are also a significant challenge that needs to be addressed. Researchers are exploring various strategies to reduce the levels of ANFs in pea protein, including genetic modification, fermentation, and enzymatic treatment (Karlund et al., 2020). In addition, the development of pea varieties with reduced ANF content could help increase the utilization of pea protein in the food industry.

Recent studies have investigated the use of Lactic Acid Fermentation (LAF) in improving the properties of pea protein. Pea protein inoculated with Lactobacillus casei displayed the best properties among other samples, regarding the aroma and bitterness (Garcia Arteaga et al., 2021). LAF with lactobacillus species was able to reduce the presence of aldehydes like hexanal, heptanal, and pentanal, which are products of oxidation (Ben-Harb et al., 2019). Finally, LAF decreases the ANFs of pea protein samples and increases their sensorial properties (Pontonio and Rizzello, 2021).

Research objectives

The current study aims to develop a fermented powdered protein and investigate the volatile compounds in comparison with their liquid counterparts and the initial sample prior to fermentation. In addition, various applications based on these proteins will be designed and the end-products of these applications will be evaluated for their bioavailability and sensorial properties.

Materials & Methods

Pea protein Isolate 85A (also known as Plantaris pea protein), 85B and 80 were provided by AGT Foods and Ingredients (Regina, Canada). Also, syrup SIRODEX 410 (Tereos, Moussy-le-Vieux, France), yeast extract (Sigma-Aldrich, St. Lous, United States), protein hydrolysate and Proyield Pea PCE80B (FrieslandCampina Ingredients North America, Delhi, United States) were to develop a fermentation medium. Set of cultures were given by the Contract Research Organization (CRO). These cultures were named Culture A, Culture B and Culture C.

Formulation

Fermentation mediums (7.5% protein) were prepared by adding pea protein isolate gradually to demi water while stirring with an overhead stirrer. Syrup, yeast extract and protein hydrolysate and were selectively added and mixed into the mediums according to the experimental design.

Processing Conditions

The medium that was formulated was pasteurized (73˚C ; 15 s) and homogenized (150/50bar). Afterwards, the temperature was set to 42˚C and the cultures were added to the medium in different dosages. The water bath was set at 42◦ C, which was the fermentation temperature, and was left overnight, for approximately 12 hours. Previously, the buckets and stirrers that were used were autoclaved at 121 ˚C for 60 min. During that time, the pH kinetics were measured, using a PASCO system with wireless pH probes. After the fermentation, samples were neutralized with a mixture of sodium hydroxide and potassium hydroxide at a pH of 7.0, then pasteurized (80˚C; 30 s), homogenized (150/50bar) and then spray dried using a Buchi mini Spray Dryer B-290.

Analytical Methods

High-performance liquid chromatography (HPLC) was employed to quantify the sugar contents and spot the differences of both the fermented samples and the raw fermentation mediums. Furthermore, the protein contents and elemental compositions of the raw fermentation mediums were determined using the Kjeldahl method and inductively coupled plasma (ICP) spectroscopy, respectively.

The identification of both newly formed volatile compounds during fermentation and original plant-based volatile compounds after fermentation was performed using gas chromatography mass spectrometry (GC-MS). To this end, samples were collected before and after fermentation (4 g/vial) and sent for GC-MS measurements by internal analysts.

Lastly, a sensory evaluation was conducted.

The evaluation comprised three phases. In the first phase, the participants were presented with two samples: a reference solution consisting of 80% AGT protein and 6% protein, and a fermented pea protein solution with a 6% concentration, which was produced at the Contract Research Organization (CRO). In the second phase, a 6% fermented pea protein solution produced using the cultures A and B as compared to the reference solution in a sensory test categorized as "Detailed comparison to reference". Also, participants were asked to evaluate, which of the samples was deemed “most neutral”.

Results & Discussion

Fermentation of the pea protein medium was conducted with the three different set of cultures that were mentioned: A, B and C. By keeping the starter culture stable and varying the adjunct cultures, it was found that all samples containing Culture B displayed a faster acidification rate. However, sensory screening revealed that the taste of these samples was not acceptable due to a sour aftertaste. On the contrary, Culture A had enhanced organoleptic properties.

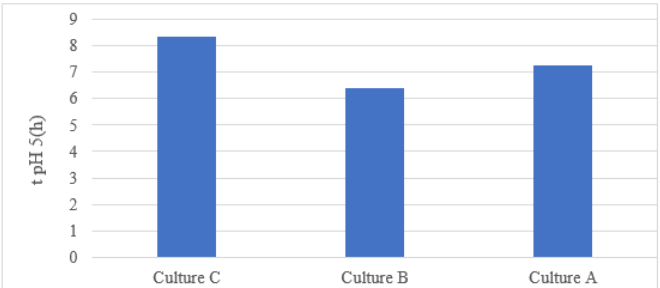

Figure 2. The time taken for the pea matrix samples, inoculated with various combinations of cultures, to reach pH 5.

By reviewing the major differences between the samples (Table 1), the protein levels dropped after fermentation (from approximately 77% to 67%), while carbohydrate levels significantly decreased from 1% to below 0,1%, indicating the metabolism of microorganisms that converted glucose into lactic acid. This was confirmed by the increase in lactic acid detected in all of the samples. The addition of 10% NaOH/KOH for neutralization resulted in an increase in minerals, particularly sodium and potassium.

Table 1. Differences between the AGT 80% (reference) and a fermented pea protein, inoculated by Culture A.

Sample	Protein %	Glucose %	Sodium (Na) %	Potassium (K) %
AGT 80%	77,5	0,8	0,88	0,033
Culture A	67,4	<0,1	2,1	1,7

Through bibliographic research, during the volatile compound analysis, it was determined that hexanal, benzaldehyde, pentanal and DMDS are largely contributing to the off-flavor of the pea protein, while diacetyl enhances its organoleptic properties. (Fischer et al., 2022, Engels et al., 2022, Schindler et al., 2012). Thus, these compounds were analyzed during the GC-analysis.

Results indicated that fermentation had a positive impact, mitigating all of the off-flavors and increasing the diacetyl levels.

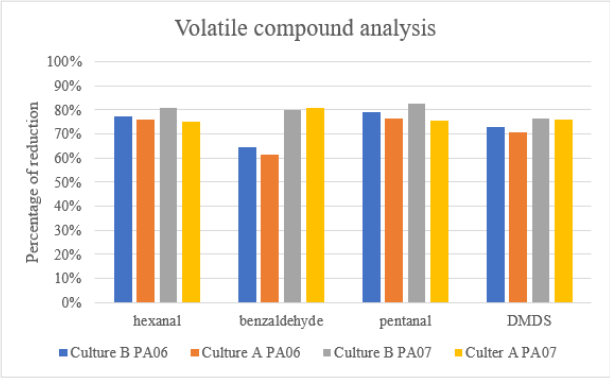

Figure 3. Percentage of reduction of the volatile compounds of fermented pea protein samples. A and B refer to the cultures that inoculated the pea protein sample, while PA06 and PA07 refer to the number of the trial.

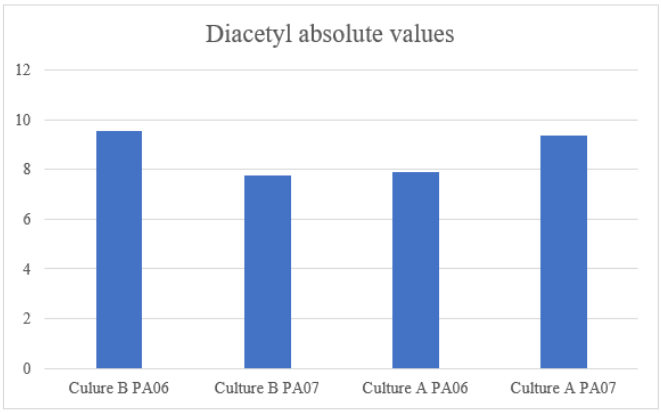

Figure 4. Absolute values of the diacetyl levels. PA06 and PA07 refer to the number of the experimental trial, while A and B refer to the cultures that inoculated the pea protein solution.

During sensory evaluation, when a fermented pea protein sample was subjected to the sensory evaluation and compared with another fermented pea protein, most of the participants chose the 2nd protein as more neutral, as the protein that was developed in this Thesis was deemed as sour, limey and bitter.

Conclusion

Among the tested starter cultures, Culture A was found to impart desirable techno-functional properties and aroma to the pea protein medium, facilitating its processing through various equipment, with increased diacetyl levels, masking off-flavors of the pea protein, and enhanced its nutty aroma. The inoculation by the set of cultures resulted in fast acidification during lactic acid fermentation. In addition, the result of mitigating the off-flavors was repeatable in the experimental trials. However, when the developed protein was compared to another fermented pea protein, people preferred the second one. As most people described the taste bitter and caustic, it is a safe assumption that the organoleptic properties affected the choice of the participants. Experimentation with alternative caustics should be explored to reduce the limey aftertaste left by the NaOH/KOH 10% mixture, which was crucial for people not to prefer the protein during the sensory tasting. In addition, to obtain more precise and reliable results, future sensory analyses should employ trained panelists and utilize more descriptive, qualitative and quantitative methods. Further exploration of the fermentation process could yield significant improvements in production time. Fermentation methods and microbial selection could be differed from that one mentioned here: it would be interesting to use LAF as a precipitation step during the production of pea protein isolates from pea concentrates. In this way, energy and production time is halved, as there is no need to spray dry the pea concentrate twice to produce a fermented pea protein.

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Circularity in Industrial packaging

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Profile in a nutshell:

- Master of Science in Food Innovation and Product Design (FIPDes) specialization in Food Packaging and Logistics at AgroParis Tech (France), Technological University Dublin (Ireland) and Lund University (Sweden).
- Bachelor of Technology in Food technology.

Interests:
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The executive summary provides a concise overview of the key findings and recommendations from the master's thesis report focused on mapping and critically analyzing the industrial packaging system between suppliers and Electronic Manufacturing Service (EMS) for components packaging of two complex electronic products.

Introduction

This master's thesis explores the sustainability and the circularity of industrial packaging of components for complex electronic products. The research aims to gain insight into the structure of the packaging system between the suppliers and the manufacturers (EMS) and evaluate its circularity to identify the opportunities and challenges for future improvement.

Research Problem and objectives

The lack of proper communication and documentation regarding packaging materials has hindered a comprehensive understanding of the system. Therefore, the study aimed to examine the structure of the packaging system, assess its circularity in terms of handling packaging materials, and identify opportunities and challenges for making the system more circular in the future.

Methodology

The study employed a methodology that included supply chain mapping, data collection from Axis databases and interviews, material flow analysis, energy and carbon dioxide analysis, SWOT analysis, and a sustainable packaging scorecard.

- Supply Chain Mapping: Mapping of the supply chain to determine the product characteristics, and different packaging levels and to identify the different actors involved in the supply chain.
- Data Collection: Quantitative data acquired from Axis databases. Qualitative data acquired through interviews with different key actors throughout the supply chain.
- Material Flow Analysis: Material flow performed by analyzing the inflow of material with the outflow into the waste stream.
- Energy and Carbon dioxide equivalent analysis: Determining the amount of energy needed and carbon dioxide equivalent produced by the packaging.
- SWOT Analysis: SWOT analysis performed on different packaging materials to identify positive and negative contributions to the product and the environment respectively.
- Sustainable Packaging Scorecard: A five-point scale for three different principles, effective, efficient, and cyclic with different functionalities.

These methods enabled a comprehensive assessment of the industrial packaging system's sustainability and circularity.

Results and Discussion

The study's findings provided valuable insights. Firstly, there is a lack of comprehensive information and specifications about packaging materials, which limits a complete understanding of the packaging system. As a result, actions are often reactive rather than proactive. In terms of recycling, the study revealed encouraging results, with high percentages of component packaging being recycled. However, the focus of waste management is still towards a linear approach rather than embracing circular practices. The findings also highlighted opportunities for improvement. Enhancing communication, promoting greater material reuse, and investing in improved recycling facilities emerged as potential paths for progress. However, challenges such as varying stakeholder locations and differing sustainability perspectives pose obstacles to achieving a fully circular packaging system.

Based on the study's findings, several recommendations are proposed. Firstly, it is crucial to enhance the communication and documentation of packaging information among the actors involved in the supply chain. This will facilitate a better understanding of the industrial packaging system and enable proactive management. Secondly, efforts should be made to promote the circular handling of packaging. This can be achieved by exploring strategies to increase the reusability of packaging materials through standardization of materials and sizes. Lastly, conducting a comprehensive life cycle analysis of the entire supply chain will provide a comprehensive evaluation of its sustainability and circularity. This analysis will identify additional areas for improvement and guide future decision-making.

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Link to reference list: https://pdf.ac/E4X1f

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