FIPDes

Food Innovation & Product Design

FIPDes Day 2018
International talents in Food Innovation and Product Design

Students' Book of Executive Summaries

Congratulations to the FIPDes Cohort 6 !

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Talk about your master thesis : it is important

"You have proven yourselves talented, capable, interested and curious young professionals»

As a group, you represent different parts of the world and, in the past two years, became acquainted with others interested in the same knowledge areas: Food Innovation and Product Design. An international master program is one of the best ways to start a successful career. You enter the program yearning for new knowledge, and you complete the program with a clear vision of the future. You have been apart for one year, studying the different strands within the program. This early September week in 2018, you meet again, and Paris will rejoice with you. Welcome back to where it all started!

It is an honor to write a few lines to you just before you start your working lives. A master thesis does not only present a study you have conducted or demonstrate your own knowledge in the area. Writing a thesis is also a way to both learn and practice critical thinking. The developments in science follow the developments in society, and scientific results may become obsolete over time. Your ability to think critically, however, will stay with you. Your work on your master theses thus has also prepared you to be able in the future to determine the quality of new developments in your knowledge areas. Such ability is crucial when research findings reported in the media can in fact be fake news or alternative facts.

Your theses' findings will undoubtedly contribute to sound innovation, product design, and sustainable development. To communicate research results clearly and to a wide audience at that is both an ability that can be trained, and a skill that can be developed. It is quite likely that more people will be prepared to listen to you talk about your theses than to actually read them. You will use your oral language to present, argue and discuss your findings, and you must do it well.

Successful oral communication of written work entails that you adapt your language and other forms of expression in the most appropriate way for the situation at hand. When you communicate your results to those who are already familiar with the subject, you use specialist terminology that works both as a bridge and a shortcut between you and your audience. It is always easier to talk to specialists than to non-specialists because we can use these shortcuts that are part of our training. When speaking to the non-specialist audience, on the other hand, you must often simplify

your language without diminishing the complexity of your subject. This may be a daunting task.

In the future, you will be asked to tell others about your work; for example, you may be asked to present your findings to a prospective employer. Sometimes, you will have 20 minutes at your disposal, sometimes no more than three minutes. Are there any general rules you can follow to make your presentations in any format a success? Yes, there are. Here, I have formulated four, rather general rules:

1. Ask the question "What do I want my audience to remember?" By answering this question yourselves, you will be able to focus on the most important part of your message. Build your presentation around your answer.

2. Start by presenting the problem you have investigated. If there is time, mention why you have chosen it.

3. Tell the audience what is the solution you propose for your problem, what your findings were.

4. Motivate why yours is a viable solution to the problem, and mention what other problems your solution may solve in the future.

These rules are rather basic, simplistic and very common sense, and therefore really impossible to challenge. Who in their right mind would choose not to mention the problem they worked on, or omit mentioning the results and the benefits of the solution they proposed? Nevertheless, these four rules require you to think your presentation through thoroughly. Moreover, you will need to rehearse your presentation several times before you are able to speak with sufficient gravitas and credibility.

Those of us who are here in Paris this week know the extent of your work: you conducted your investigations, you analyzed your results, you compiled them in well-written master theses, you have subsequently discussed and defended your theses. You have proven yourselves talented, capable, interested and curious young professionals. Together with your teachers, I wish you to realize your potentials in the best possible ways.

Best regards!

Cecilia Olsson Jers
Invited professor and supervisor
Malmö university, Sweden

The effect of some fermentation parameters on the interaction between Lactic Acid bacteria and yeast in sourdough

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Introduction

Sourdough bread is a traditional product with great potential and promising future. To use this potential, the interactions between LAB and yeast must be better understood (Gobbetti, 1998). On the other hand, sourdough has a very complex microflora. For this reason, starter cultures to be used in sourdough production should be carefully selected (Carnevali et al., 2007). The dominant flora in the sourdough is represented by yeast and LAB.

Research objectives

- To better understand the interactions between selected 2 yeast (Maltose positive and Maltose negative) two bacteria strains (heterofermentative facultative and heterofermentative obligatory) by focusing the effect of inoculation quantity.
- To examine particularly the production of acetic acid, lactic acid, ethanol and CO_2 which are the main interest about sourdough.

Methodology

102 sourdoughs were prepared (DY 155) by mixing 400 gr flour, 220 gr water and the certain quantity the starter that is sown in the table1 Two yeast and two bacteria strains were used in starter preparation; S. *cerevisiae* Maltose negative, *S. cerevisiae* Maltose positive, *L. brevis and L. plantarum*. The mixture was kneaded for 2 minutes at 1st speed and 30 seconds at 2nd speed. The fermentation was carried out at 30˚C for 24h in a water bath. Samplings were made during fermentation at T0h, T16h, and T24h. However, pH and CO_2 production were measured continuously during 24h. Acids, sugars and alcohol production were analyzed by HPLC.

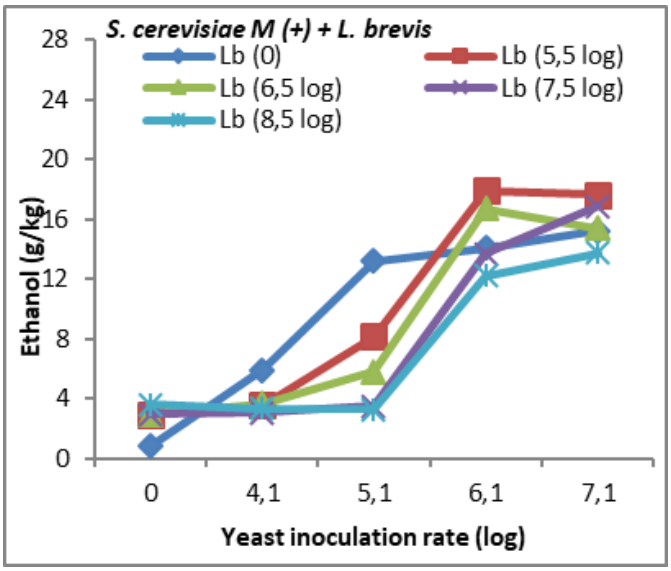

Figure 2. Ethanol production

Results and discussion

At specific ratios between *L. brevis* and *S. cerevisiae* M (+) acetic acid (Fig. 1), ethanol (Fig. 2) and gas production increased compared to single inoculation.

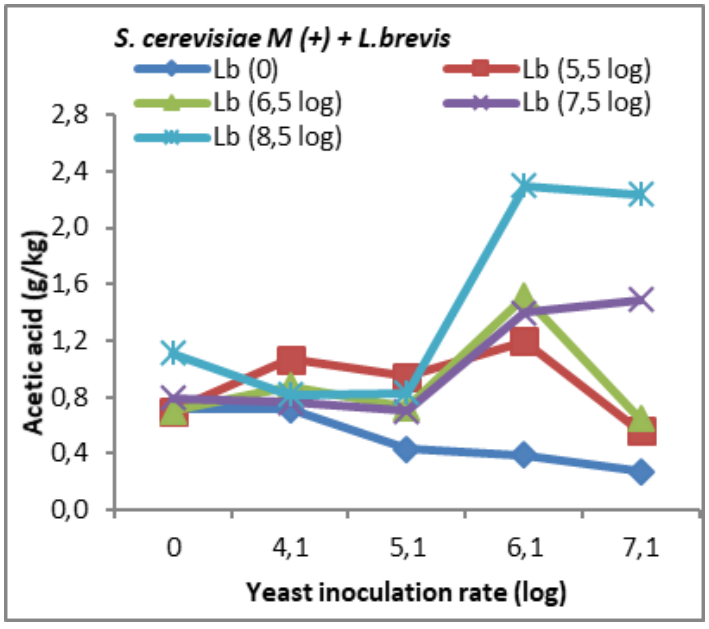

Figure 1. Acetic acid production

In the combination of *L. plantarum* and *Saccharomyces cerevisiae* M (+) gas production and ethanol (Fig.3) increased also but lactic acid (Fig.4) decreased compared to the production at single strain inoculation either of yeast or bacteria.

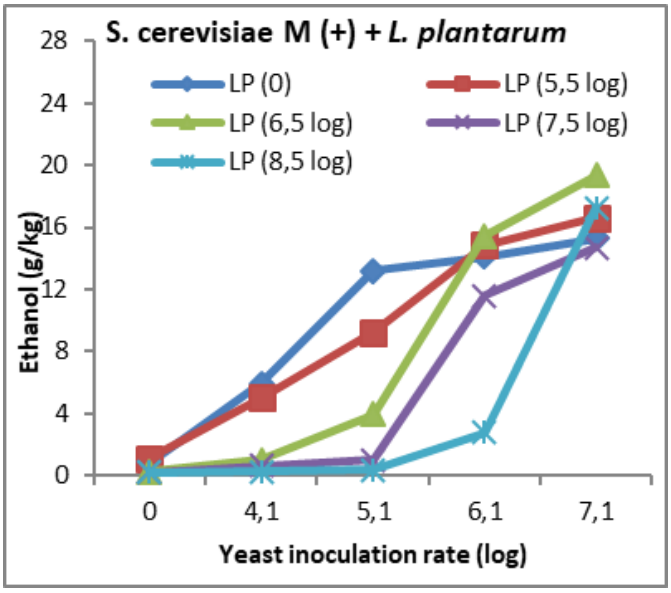

Figure 3. Ethanol production

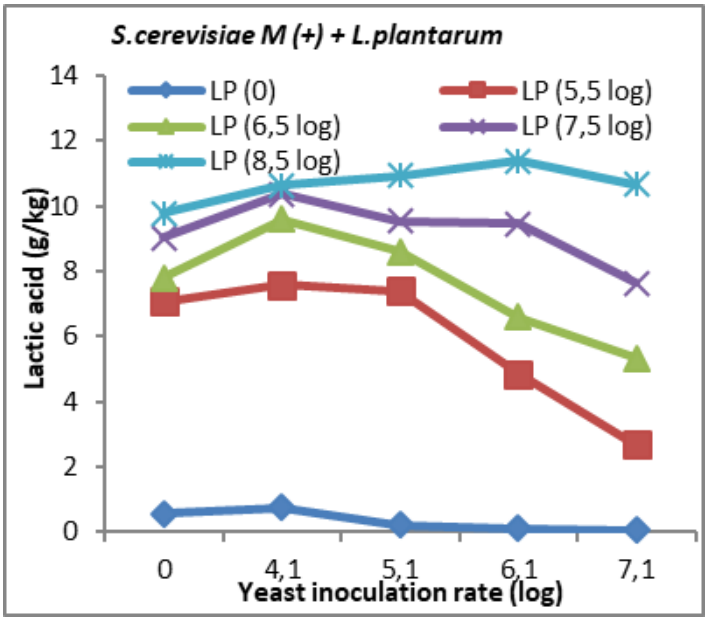

Figure 4. Lactic acid production

Conclusion

There is a clear interaction between yeast and LAB and metabolic shift under some conditions.

An increase of Acetic acid, Ethanol and gas production was observed at certain innoculation ratios. An example is the synergy between the yeast *Saccharomyces cerevisiae* M (+) and *L. brevis* at specific ratios that enables the production of more metabolites like acids,gas and ethanol.

This result happens because of the metabolic degradation of complex sugars by the yeast and production of fructose which is consumed by the bacteria. Leading to the shift from producing lactic acid to produce ethanol and gas in the case of the combination between *L. plantarum* and *Saccharomyces cerevisiae* M (+).

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Effect of leavening time on pizza digestibility: an *in vitro* approach

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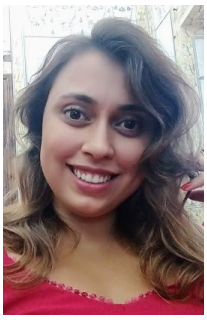


Introduction

Type-2 diabetes (T2DM) is dramatically increasing worldwide and the expectation for the next 22 years is that it will continue to do so (Guariguata *et al.,* 2014). A diet rich in carbohydrates with a high glycemic index is a well-known risk factor for diabetes and several studies have been conducted in order to modulate starch digestion and glucose release as an effort to prevent and ameliorate T2DM cases (Soong et al., 2014).

Starch digestibility can be affected by factors such as macromolecular structure, combined intake of carbohydrates with fat, proteins, dietary fiber or other nutrients as well as by food processing (Tian*et al.,* 2018). The rate starch is digested influences insulin response and blood glucose concentration. In order to advise diabetic and prediabetic patients on an appropriate and healthy diet it is necessary to understand the mechanisms underpinning glucose modulation by a food. Although glycaemic index (GI) is a widely used measure to evaluate the effect of a food on blood glucose response it is not fully accepted by the research community. Many parameters are known to affect glucose absorption and digestibility such as the rate of digestion, food structure and preparation, type of the starch, presence of antinutrients (i.e. α-amylase inhibitors), transit time and amount of fiber, fat and proteins present in the food matrix (Wong & Jenkins, 2007).

Processing and preparation of foods such as heating process, water activity and time of cooking are all parameters that influence starch structure and digestibility (Pellegrini & Fogliano, 2017). Starch is present in foods in form of granules and the processing of a food can disrupt these granules resulting in more accessible molecules for the action of enzymes. During baking chemical kinetics reactions are accelerated and it promotes dehydration and non-enzymatic browning such as Maillard reaction (MR) and caramelization (Wu *et al.,* 2017). MR can interfere with baked products quality, its nutritional aspects, and it is responsible for desired changes such as aroma, taste and appearance of the food which majorly influence consumer acceptability (Hellwig & Henle, 2014).

Research objectives

The primary objective of this study was to clarify the digestibility of a typical leavened and baked product, like pizza, by using an *in vitro* approach. Pizza samples were produced by using a typical Neapolitan recipe and different leavening time for the dough. *In vitro* digestibility of carbohydrates and proteins were tested by applying to the pizza samples an enzyme digestion protocol validated to mimic human digestion and by analyzing glucose and protein hydrolysis rate in the digesta collected at salivary, gastric and intestinal steps. In addition Maillard reaction products such as HMF and melanoidins were analysed in the pizza.

Methodology

Dough

Water (38.9%), salt (2%) and yeast (0.2%) were mixed (IM5M, Mecnosud, Italy) and then flour (59.3%) was added over a 10 minutes period at that point the dough was mixed for 20 minutes. Once done it was cut in 150g pieces and placed in an incubator (MIR-154-PE, Panasonic Healthcare CO., Japan) for leavening. The dough was fermented at 25˚C for 8 hours then it was placed at 4˚C for 16 hours and for the last 6 hours of fermentation it was kept at 25˚C. The volume of the dough was recorded during the leavening period as a measure of fermentation.

Pizza

The dough was rolled in a 25 cm diameter disk and baked at 220˚C for 10 minutes with tomato sauce (80g) (FQP100XE, REX, Electrolux, Italy) in different fermentation times: no fermentation (sample 0), 2 hours (sample 1), 4 hours (sample 4), 6 hours (sample 6) , 8 hours (sample 8), 24 hours (sample 24), 26 hours (sample 26), 28 hours (sample 28) and 30 hours (sample 30) of fermentation. Once the pizza was cooled down it was weighed (400 AR, Gibertini Europe, Italy), freeze dried and homogenized in a knife mill Grindomix 200 (Retsch, Haan, Germany).

In vitro digestion

In vitro digestion was performed based on the Infogest protocol (Minekus*et al.,* 2014) with some modifications. The modifications in the protocol were the use of distilled water instead of the simulated salivary fluid for the salivary step of digestion and for the simulated gastric and intestinal fluids the volume was adjusted to 15 mL in order to collect digesta in each step of the digestion for the analysis further conducted.

Glucose determination

Glucose was determined by quantitative enzymatic analysis. The procedure was done following the glucose assay kit instructions (GAGO-20, Sigma-Aldrich, St Louis, MO). Samples were prepared by the dilution of 200 µL of digested pizza samples 50 times in distilled water.

Degree of hydrolysis of proteins

It was determined by analysing the free amino groups in the digesta. The *o*-phthalaldehyde method described by Spellman *et al.* (2003) with slight modifications was used. Lyophilized pizza samples (50 mg) were solubilizedby adding 1.5 mL of trichloroacetic acid 5% (Sigma-Aldrich, Milan, Italy).

Quantification of MR products

Melanoidins content in the pizza samples was determined following the method as described by Foglianoet *al.* (2011) except for the incubation time of the sample with Tris and protease Pronase E which was of 40 hours at 37°C. 5-hydroxymethylfurfural (HMF) was determined following the method described by Fiore *et al.* (2012).

Statistical analysis

Data obtained for glucose determination, quantification of protein hydrolysis and HMF were analysed through Excel Software (2010) to obtain mean, standard deviation, ANOVA and T-test. For Anova and T-test the data was analysed at 0.05 significance level. Melanoidins quantification and pizza volume were also analyzed through Excel Software (2010) to obtain mean and graphic representation of the results.

Results and discussion

Physical properties during processing

An increase of 360% of volume from time 0 (no fermentation) to 30 hours of fermentation was observed. There was a *plateau* between times 0 and 2 and then the dough started growing in a consistent fashion. With the fermentation and consequently, the increase in volume over time the weight loss of the pizzas decreased. This could be a consequence of the yeast growth and the incorporation of the water into the matrix preventing water loss during baking.

Glucose concentration

Leavening duration did not influence the total glucose content of the pizza samples (**figure 1**) and results showed to be in line with literature for white wheat bread (Ferdet*et al.*, 2006).

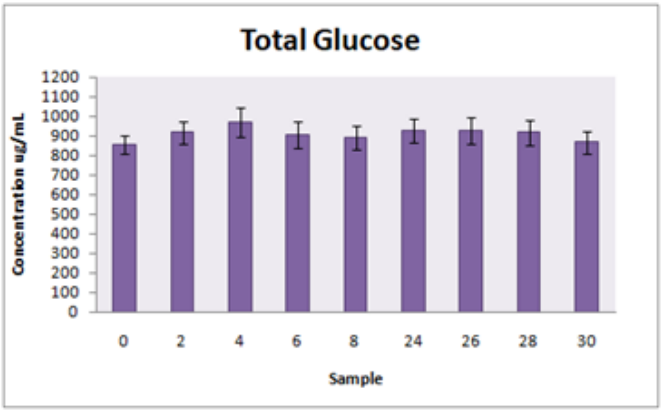
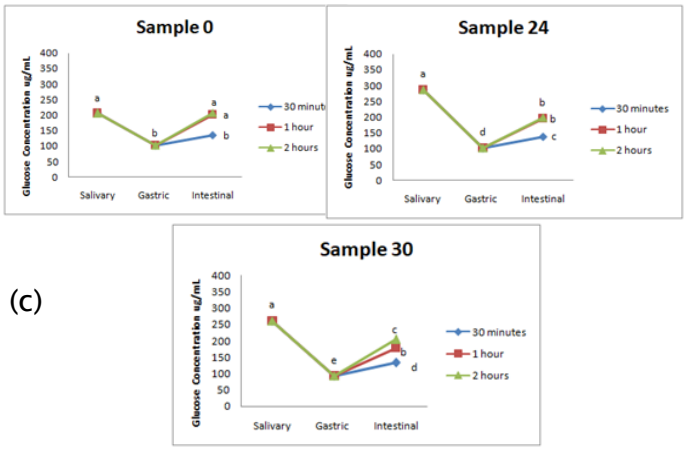


Figure 1. Total glucose concentration. No differences between samples by ANOVA

However, the concentration of glucose in the digesta at different steps of digestion showed some differences between samples. In the course of fermentation glucose digestion initially showed less differences between salivary and intestinal (1 and 2 hours) phases as well as for gastric and intestinal after half hour digestions (**figures 2a, 2b, 2c**).

Figure 2: In vitro bioaccessibility of glucose from samples time 0 absent leavening (a),after 24 hours of fermentation (b), after 30 hours of fermentation (c). Different letters indicate significant differences between glucose concentration by ANOVA and Tukey t-test

(a) (b)



(c)

These differences were mainly due to the content of glucose in the salivary digesta that differed between samples by showing an increase at longer fermentation time points compared to no leavened sample and in differences between the gastric phase glucose of some samples (**Figures 3 and 4**)

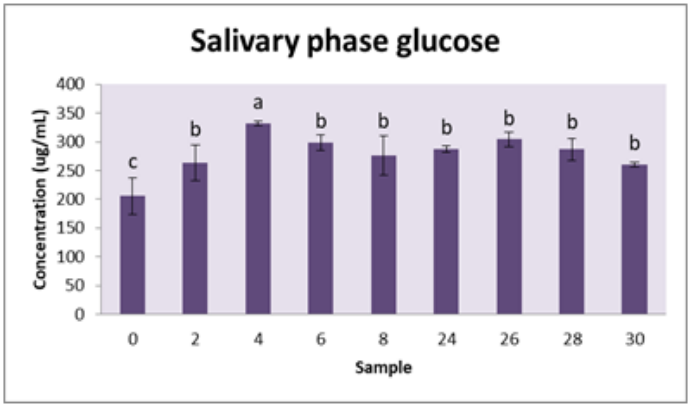


Figure 3. Salivary phase glucose. Different letters indicate significant differences between glucose concentration by ANOVA and Tukey t-test

This means that by increasing the leavening time of pizza dough the glucose becomes more bioaccessiblealready from the early steps of digestion.

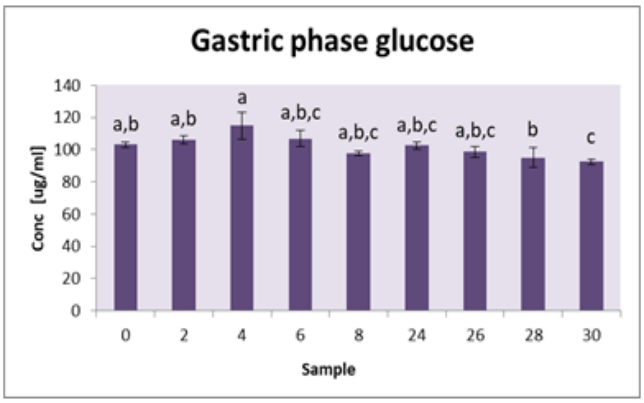


Figure 4. Gastric phase glucose. Different letters indicate significant differences between glucose concentration by ANOVA and Tukey t-test

Free amino groups and MR products

There were no significant differences between samples for the concentration of free amino groups. This finding was in disagreement with previous evidence in bread showing changes in soluble amino acids, peptides and proteins in white bread that are strictly related to microorganisms and enzyme activities (Barber *et al.*, 1989; Thiele *et al.*, 2002). However, free amino groups are also used during MR, which occurs when reducing sugars and amino acids, proteins, and/or other nitrogen-containing compounds react under he.at treatment (Purilis, 2010). At this regard, concentrations of HMF varied from 2.8 to 4.3 µg/g of sample with the highest value in sample 6 (**Figure 5**). Fermentation was important for HMF formation as it is inversely correlated with volume increase of the dough and both chemical (such as release of glucose, maltose and maltotriose) and physical parameters (like volume and availability of water) concurred to its formation. This can be an indicator that yeast assimilated a higher amount of free amino groups as it grew through leavening time.

The trend observed for melanoidins was similar to HMF with a peak of concentration after 6 hours of fermentation.

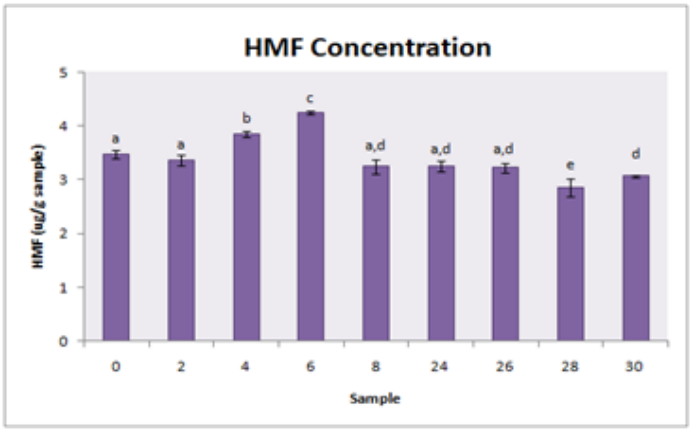


Figure 5. HMF concentration. Different letters on the bars indicate significant differences between samples by ANOVA and t-test

The decrease that occurs after 8 hours of fermentation can be related to the lower amount of free amino groups available.

Formation of melanoidins are highly dependent on the amount of amino groups available and as fermentation takes place the yeast is more numerous these free amino groups may become scarce resulting in less MR.

Conclusions

The fermentation time influenced physical parameters of the pizza as the water retention, the bioaccessibility of free glucose and the formation of MR products. The weight loss of the pizza samples decreased simultaneously with the increase of fermentation time demonstrating that there were structural changes in the dough throughout fermentation. These changes were responsible for the other parameters variations studied especially for those related to MR.

Total glucose content upon digestion did not change significantly between pizza samples subjected to different leavening times but results showed that the leavening time interfered with glucose bioaccessibility along the gastrointestinal tract. Data also showed that HMF increased during the first 6 hours of fermentation reaching a peak followed by a decrease for sample 8 and a stable concentration during the last few hours. Being MR dependent on heat treatment, sugar and amino groups, it is likely that the lack of differences found for free amino groups and total glucose are directly related to the formation of MR products (HMF and melanoidins). In addition, yeast metabolizes amino groups for growth and it interferes with MR formation rate thus making these compounds less available. This could explain the decrease of HMF and melanoidins concentration at long fermentation times.

This study elucidates how the duration of fermentation of pizza dough can change the digestibility of carbohydrates and proteins and it can be an aid for the development of new leavened and baked foods intended for lowering postprandial glucose.

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Towards a hybrid agile-stage-gate process to support innovation: Exploring challenges and opportunities in the dairy industry

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Introduction

Today, globalization increases competition, and product life cycles are decreasing in almost all technology-intensive industries - companies must deliver new products, and more customer value, faster than ever to stay competitive. Supporting innovation process is a strategic weapon to get better at new product development. Stage Gate process has been described by Robert Cooper in 1990 to support new product development: an initiative or project is divided into distinct stages or phases, separated by decision points (gates). This powerful process has been used through the world for almost 30 years – with good results. However, this process must be reviewed regarding today's global market challenges (short product life cycle, fast delivery, high competition..). Originally, Agile set of methodologies have been developed for the software industry; nevertheless, hybrid processes combining agile and stage-gate elements may offer a more flexible alternative to conventional systems. This master thesis proposes to explore an hybrid Agile stage gate process, which incorporates Agile mindset and methods to the traditional Stage-Gate process – through a case study in the Dairy industry.

Methodology: case study

Case study is preferred when the focus is on contemporary phenomenon within some real-life context (P.Sami,2016). This master

thesis' research question is a theoretical proposition; however, one of the best way of trying and assess performance of models is to bring theory and real-world face to face. Besides, case studies rely on multiple source of evidence and allow to explore a situation with many variables of interest. Lots of information can be collected from a single unit as well as from a larger group of units. Case study will allow the researcher to link information, to address the research question with a broad view on the subject; and to see how different units interact together to, finally, form the case study on its own. This master thesis case study takes place at Danone Nutricia Research centre in Palaiseau (France). First, the researcher will go through the stage gate process used in Danone; then he will explore hybrid Agile Stage Gate process opportunities applied to the dairy industry. collected information will come from intern documentation, direct observation, participant observation & semi structured interviews.

Empirical study

First, a status of how innovative projects are managed in the dairy industry has been done. Then, the researcher studied the pros and cons of stage gate process in supporting innovation in the dairy industry to came up with the fact that disruptive innovation (new products from the company point of view - the reference frame is the company) may be the perfect candidate for hybrid agile stage gate process. Disruptive innovative projects are the one supposed to face substantial uncertainties – thus need more agility & flexibility in the process. Short term working sessions (sprints), early prototyping and user tastings are the main identified advantages of using hybrid stage gate process for disruptive innovation projects.

Discussion

Changing the process and methods is a lot of work, as adjustments will be necessary; putting a new process in place is also time consuming. Besides, how to be sure that agile and stage gate processes are compatible in the dairy industry? Another gap identified in the literature concerns measurement tools to evaluate processes' performance - measuring the impact of new hybrid model is essential. Furthermore, a tangible product is supposed to be delivered at the end of each sprint: which format for prototyping a dairy product at an early stage? The researcher also discussed the opportunity to improve working atmosphere using more agile and flexible process, as well as improving the business responsiveness & competitiveness.

Conclusion

Efficient work organization and robust project documentation have been identified as major benefits to the use of the stage gate process. On the other hand, to overcome rigidity and linearity constraints, the researcher proposes to look at agile set of methodologies and suggests integrating some of agile tools (sprints, early prototyping & user tastings) to the current stage gate process to create a new hybrid process. Doing so, the objective is to break the linearity and rigidity of the stage gate process and gain in competitiveness. In the current stage gate process used in the dairy industry, prototyping and consumer testing are already an important part of the process. The idea is to emphasis them, to make them more powerful and decisive. Points of vigilance have been identified: which format for early prototyping considering that the product developed is a dairy food product which requires

raw material processing, as well as quality and food safety guarantee. Further, having two systems in parallel to support new product development process can be a challenge to manage. As such, Agile tools cannot be implemented to the stage gate process, adapting the actual agile tools to the dairy product development system will be required. Finally, contribution to the academic research of the topic and to the industry were made. Indeed, literature provides few hybrid agile stage gate case studies in the industry (automobile, electronic, packaging...) but none of them was from the food industry. This study brings insights on pros and cons of stage gate process in the dairy industry as well as produce knowledge about opportunities of hybrid agile stage gate process for dairy food product development - and provides a starting point to empirical findings on this emergent topic.

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Recyclability by Design of flexible packaging

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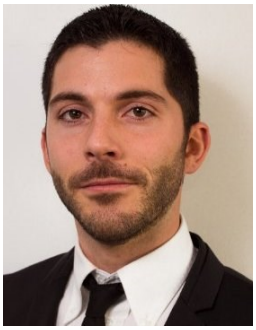

Introduction

Flexible packaging has been increasingly growing in the market and besides its benefits, its recyclability needs to be addressed. Understanding the key issues of sorting and recycling this packaging category is crucial and its design could lead to a better effective recyclability. The Early Life Nutrition portfolio is presence worldwide and different flexible packaging should be re-design to achieve its 100% recyclability.

The portfolio of ELN (Early Life Nutrition) flexible packaging was analysed to have a worldwide overview of the different film strategies by region. These structures were analysed with the information gathered from the different interviews with specialists and the bibliographic research. The scope of the projects was narrowed using a forecast sale, giving this study a business approach and being able to prioritize between the multiple categories.

The data from the different packaging structures was extracted from an internal data base. This first analysis brought together specifications from over 9 different factories and 40 packaging lines worldwide.

The different issues identified along the recycling stream were used to provide new materials for the flexible packaging. This new material will ease the recyclability due to their structures and the ways the current technologies and recycling facilities sort and recycle the packaging.

Research objectives

Purpose: To understand the recyclability issues of flexible packaging as part of the post-consumer waste streams

Goal: To propose Nutricia Research new films materials that could be implemented in their portfolio with a higher recyclability rates than the current.

Methodology

This research was based on primary research (literature research and different data bases) and primary research (interviews with different specialist in the field). Working together with different specialist of flexible packaging either from factory, purchase, packaging development or circular economy was possible to asses this challenging topic.

Results and discussion

Multi-material vs mono-material. Not all materials existing nowadays can be sorted and recycled being the main accepted resins: PET, PE and PP for rigid packaging and PE for flexible packaging. Therefore, moving to a simpler structure, PE if possible, seems the right way to be accepted by the current flexible pack streams.

Bio-based vs biodegradable. When considering bio-based and biodegradable polymers in the design, it is important to consider that biodegradable packaging is not currently accepted by mechanical recycling. Therefore, if the aim of this research and goal of the company is to create a more circular economy, this kind of polymers should not be considered when designing a flexible packaging since besides its other benefits, they won't become a new resource after its recycling.

On the other hand, bio-based materials such as Bio-PE and Bio-PET could be a better option.**Multilayer vs multi-material.** The design of the packaging could be done by including barrier materials that are compatible with the main polymer of the structure. For instance, by including multiple layers from the same material with different orientations. This is the case of Borstar®-based Full PE Laminate, a combination of bimodal polyethylene technology and machine direction oriented (MDO) processing technology.

Inks and additives. When it comes to inks and additives there are some restrictions as well. For instance, to have a compatible (i.e. recyclable) film, its printing should be at least lower than 50% of its surface, otherwise it will be considered as a low compatible product and will end up most likely in energy recovery. On the other hand, the incorporation of additives must be limited and adjusted since it could affect the way the materials are optically recognize as well as its density.

Conclusions

Thanks to the analysis and overview of the different flexible films specifications currently in used by Early Life Nutrition Division, it was noticeable that due to the complexity of the portfolio and the different matrix that those flexible films are being used for (i.e. fruit puree, milk cereals, milk powders), and specific research on each category should be implemented. As a strategy, the company could tackle together both Bag-in-Box formats (cereal and milk powder), the printable formats such as sachets and stand-alone pouch as another branch and later the pouches, which might be more complex.

The pouches usually receive a pasteurization treatment or a retort treatment and therefore

it would be necessary to adjust the materials and the spout in this category due to the elevated temperature to avoid any kind of material migration and optimize the performance of the foil. Furthermore, the new materials need to be adjusted according to the multiple packaging lines used within Early Life Nutrition factories, being necessary working together with the suppliers to develop the right material with the right machinability requirements to have at least the same outcome and capacity as the current packaging solutions

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Ecosystem of food start up development

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Introduction

Today, the belief that innovation drives competition is spread all over the world (see e.g. Debackere and Veugelers, 1999). The European Union aspires to become the most competitive economy in the world and intends to achieve this aim through innovation (Commission of the European Communities, 2000).

One instrument to promote innovation and counter this high start-up failure rate is the business incubator. This allows the start-up to concentrate on its business plan and raises the success rate.

It's important to keep in mind the totality of the incubator. Specifically, much as a firm is not just an office building, infrastructure and articles of incorporation, the incubator is not simply a shared-space office facility, infrastructure and mission statement. Rather, the incubator is also a network of individuals and organizations including the incubator manager and staff, incubator advisory board, incubatee companies and employees, local universities and university community members, industry contacts, and professional services providers such as lawyers, accountants, consultants, marketing specialists, venture capitalists, angel investors, and volunteers ((Aerts, Matthyssens and Vandenbempt, 2007)).

Regardless of the stated goals and objectives of the incubator, ''the universal purpose of an incubator is to increase the

chances of an incubate firm surviving its formative years'' (Allen and Rahman, 1985). Similarly, regardless of the incubator stakeholders' desire and political need to demonstrate the ancillary effects of job creation and economic development, the universal goal of incubatees is (or should be) to survive and develop as a corporate financial entity that delivers value to the owner(s)/shareholders (Hackett and Dilts, 2004).

Research objectives

Research follows several objectives:

- To find out the main organization, structure, resources, scope of activities, functioning, main stakeholders, management variety, business models of "incubator" called systems in the development of food/ non-food start ups
- Make propositions to determine the ideal ecosystem structure for the food startups progress
- Based on the previous objective make a valuable propositions to "FoodInnLab" FabLab/ incubator development

To achieve these and consequential subobjectives, the scope of the research includes the history and evolution of incubator called structures, their role and the evolvement of these, typology and variety of incubators, University based formats, FabLabs, accelerators as generated innovative structures. In the last section the evaluation of these complexes is designed as a linked part to the startup success emphasizing the process of incubation, outcomes of the incubator and the involvement of various stakeholders in this process.

Methodology

Taking into account the fact that the research demands qualitative analyses based on the case studies such as incubators, I have used "Case study research" developed by Robert. Yin, 2008 as a major source of method. There are 6 consecutive steps which sum up and make the complexity for the whole research: plan, design, prepare, collect, analyze and share. The major part of the methodology was contributed to the stage "collect" as implementation of interviews with various stakeholders involved in the analyzed innovation structures assigned on the certain questionnaire for such or another associate. Interviews has been implemented during two months (April-May) with 6 structures (4 from one ecosystem, another 2 each from different ones) successfully connected based on the settled dates in advance with the stakeholders via email, and lasted approximately 90min each. The interview strictly followed the structured questionnaire, in case of misunderstanding, details have been asked on point. As there was only one time interview proposed, the interviews have been recorded and then transcript into document. Accuracy was checked by asking interviewees about the correctness of transcripts via email and after approval used for the analyses of results. Interviews occurred with CEOs, managers of projects, co-founders, start uppers (actually incubated and alumni), and external stakeholders indirectly linked to the system.

Results and discussion

The structure analyses has been implemented for each innovation ecosystem to have an ***individual deep overview***.

It describes: management and services , followed by incubation process from the selection, the support provided and the fees , some highlights very much typical to that

structure: such as physical space provided, the mediation, availability of project managers, mentors, specification during work process and more.

Performance:

launch date and perspective since then, goals, the process of incubating starting from selection, space and shared facilities, availability of mentors, amount of actual and graduated incubators (which of course depends on the existing time). The **role of stakeholders** is crucial, in this research case these are: entrepreneurs, the direct and indirect partners which have influential factor in incubating ecosystem: both internal and external. The latters' representatives can be mainly the founders and investors, public organizations part of governmental and /or regional/ local policy, as well the network can include other local, regional, international partnership.

Main mission*:*

For the University based ones the main concept is to develop entrepreneurial mindset within students **.** As a sub-objectives coming job creation, economic/technological development, development of start ups in successful firms.

Business model:

It can be either within governmental policy funding, or regional/ local state finances, as well big network corporations' donations annually .

Start ups fees are considered a part of the model, however the fees are not very much concrete as in some cases delay of payment is allowed.

Target audience:

For the University based structures the target is mainly students, projects coming from them, or graduates / alumni, as well young start ups, the fact about the maturity of the team.

Location:

It was very much valued the importance of location (being close or far away from Paris) .

Selection:

Besides online application, start ups have to pitch in front of the committee to prove the concept and work they do and plans for future.

Business support:

3 incubators provide intangible support , such as network with corporates and especially with financial links (BPI), prove of prototype and further development, business model, management and marketing. For the FabLabs it is mostly prove of idea through concept and prototyping the product, further development of the product from lab scale to scale up, assistance with viability of the product and filling the market gap of that.

Mediation:

It is very much depends on the mission and functions of the structure. It needs some network with partners, thus at the beginning incubator is intermediate, after a while it can be direct.

Graduation/exit:

For the most analyzed cases, it is actually 3 years from pre-incubation, incubation and post –graduation.

Structure success:

Each incubator consider different indicators to be successful: for some it is start up survival, the entrepreneurial spirit within students, the company's growth after graduation achieving the results dreamed about.

Entrepreneur success:

The values such as: job creation, turnover, revenue, international success, viable product launch in the market, sustainable development were highlighted.

"Success depends on the ambition of the founder: it can be growth rate, number of clients or level of funding. Success is combination of sustainable project, strong team, strong differentiation of market, high value brand", said by one incubator manager.

Local/Regional impact:

There is not any objective to have a local impact or the structure is not old enough to monitor the impact, moreover some start ups come from the outside and after graduation go back, as a result their outcomes can't be considered as local impact. Moreover, there is no exact indicator to describe this impact unless the incubator is a strategic part of the local/regional policy following exact goals.

Connection with University/ Academy:

University based systems were very much open to have connection with entrepreneurial world, making start up creation very much attractive not only for students but for teaching and research staff also. Anyway , the gap between two worlds exist .

Conclusions

Taking into account the results, interest and limitations, it was proposed to further develop the study as a PhD project including more systems and stakeholders.

Several propositions were made to improve the operation and management of FoodInnLab incubator of AgroParisTech.

- Broaden the network with big variety of interested stakeholders, emphasizing big, internationally popular food/ agro-sector companies
- Attract and assist more start ups/ projects , the structure has to be more open
- Precise the exact interest scope of project / start up (to have the exact purpose equipment needed for assisting, but not all the device without any need)
- Promote entrepreneurship within students while implementing projects with/ without start up
- Give entrepreneurial help to start ups (include mentors and staff responsible for business plan or use settled connections in other structures)

The research and its objectives interested the majority of interviewees during meetings and interviews, and I have been asked to send the final document to the interviewed structures.

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Investigation on the masticatory and textural properties of the protein-fortified acorn starch gel (Dotori Muk) for the Korean elderly

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Introduction

In 2050, the number of Korean people aged 60 or older is projected to reach 21 million [1]. To maintain the optimal quality of life and health of the fast-growing elderly population, the development of nutrient-dense, tasty and easy-to-chew foods is needed [2].

"Dotori muk" (acorn jelly) is a traditional Korean dish. Made from acorn starch, dotori muk is popular among the Koreans for its distinguishing jelly-like texture. Dotori muk is ideal for elderly diet, because it is easy to chew and is consumed often by the Korean. However, its nutrient value is rather low, concerning protein intake is crucial for the elderly [3]. Besides, the elastic texture may be problematic for swallowing if not masticated properly.

Soy bean is a reliable vegetal source of bioavailable protein and has been on the Korean dining table for centuries. Besides, the previous study showed that dotori muk made with soy bean flour had the highest sensory acceptability compared to soy protein isolate, whey protein concentrates and casein. In addition, it has been reported that soy protein addition resulted in a softer texture and decreased elastic properties to a starch gel [4]. However, the effects of soy flour on the texture of acorn starch gel are hardly found from the literature.

The masticatory properties of the food represent the dynamic break down during oral processing, which are particularly important

for the elderly consumers, because they are in higher risk of choking due to the physiological dysfunctions related to mastication and swallowing [5].

Thus, the objectives of this study are:

- The effect of soy protein addition on the textural properties of acorn starch gel (dotori muk).
- The effect of soy protein addition on the masticatory properties of acorn starch gel.
- The acceptability of the acorn starch-soy flour gel (protein-fortified dotori muk).

Methodology

The acorn starch and soy flour were purchased from supermarkets.

Proximate analysis

The component of the materials (moisture, carbohydrate, ash, crude protein and crude fat) was analyzed using the methods compliant with Korea Food Code.

Differential scanning calorimeter (DSC)

The thermal properties of acorn starch and soy flour were determined with a differential scanning calorimeter (DSC, DSC 4000 System, Perkin Elmer, USA). The test was carried out by heating the pan from 30℃ to 130℃ at 10℃ / min. An empty pan was used as reference [6,7]. Triplicate measurements were performed on each sample.

Sample preparation

The control ("AS") and two protein-fortified ("AS-6SF" and "AS-12SF") acorn starch gel samples were prepared by mixing acorn starch and different levels of soy flour with distilled water. All the suspensions contented 10% (w/w) AS and the fortified suspensions had 5 and 10 % of SF. The suspensions were heated in a stainless-steel pot on a heating plate with heating rate of 5℃/min. Temperature was hold at 90 for 10 minutes to allow a complete starch gelatinization and increased AS concentration to 12% (w/w). Agitation at 180 rpm (RW20 digital, IKA, Germany) was applied throughout the process. The slurries were then transferred to a stainless-steel mold (12x12x2 cm) and set at room temperature for 1 hour before stored at 4℃ for 24 hours. The samples were cut into 1.5x1.5x1.5 cm cubes before all the experiments.

Textural Profile Analysis (TPA)

The textural properties of the gels on day 1, 4, 7 and 14 were measured using a texture analyzer (TMS-Pilot, Food Technology Corporation, USA) [8]. Textural parameters (hardness, adhesiveness, cohesiveness, springiness, and gumminess) were obtained using TL-touch software (Food Technology Corporation, USA). The testing condition was deformation 25%, test speed 200 mm/min, and trigger force 0.15N [9,10]. Sample was maintained at 10 ℃ throughout the measurement. 10 replications were performed on all samples.

Scanning electron microscopy (SEM)

The structure of the gels was examined with a scanning electron microscope (S-2380N, Hitachi, Japan). The gel sample was first freeze-dried before SEM. The dried sample was attached onto a SEM stub using a double-sided tape and then coated with gold using E-1010 ion sputter (HITACHI, Japan) for 120 seconds to obtain 10~20 μm coating thickness.

Subjects

Two groups of female participants (young group, n=11, age=24.5±1.31; old group, n=11, age =61.7±2.7) who had no significant masticatory dysfunction were recruited from Hanyang University.

Tongue strength

The maximum tongue strength of the subjects was measured using an Iowa Oral Performance Instrument (IOPI; TPS 100, Cyber Medic, South Korea).

Food bolus particle size distribution

The subjects were asked to chew the samples in a normal manner without swallowing and to spit out the food bolus after 5 (and 10) chews. Wet sieving was performed on the bolus using sieves of 9 mm, 3.5 mm, 1.5 mm and 0.1 mm apertures. The particles gathered in each sieve were then weighed [11].

Mastication parameters

The subjects were asked to eat the samples in a normal matter. Mastication time and number of chews were recorded by the researchers. 2 replications were performed on each sample with each subject.

Sensory evaluation

A 9-Scale hedonic test was conducted with 10 untrained participants (Korean female elderlies aged 62.4±2.5 years old) recruited from Hanyang University.

Statistics

All data were analyzed using SPSS software (version 23, IBM Co., USA). One-way analysis of variance (ANOVA) with Duncan's multiple range test was conducted to determine the significance of differences among groups, assessed at the $p<0.05$ level. The relationships between the textural, masticatory and sensory variables and physical properties were explored by calculating Pearson correlation coefficients.

Results and discussion

Thermal properties of the ingredients

The To, Tp and Tc of AS-SF composite increased as soy flour content increased, while ΔH_{starch} decreased as soy flour content increased (Figure 1). This might be the result of soy protein reducing the water availability to acorn starch [6 12].

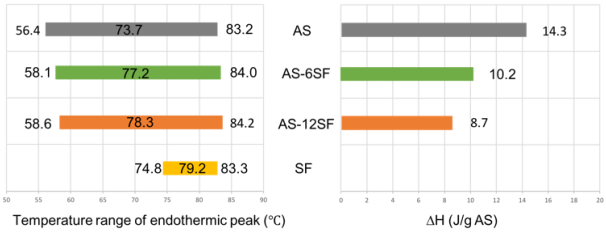

Figure 1 DSC results of the AS-SF composites

Nutrition facts of the samples

The nutrient facts of each sample are presented in Table 1. AS-6SF gel and AS-12SF had high protein contents that complied with South Korea Food Labelling Standards (2016) and EU regulation (EC) No 1924/2006 for "source of protein" claim.

Table 1 Nutrition facts of the gels

	AS[1)]	AS-6SF*	AS-12SF*§
Energy (kcal/100g)	43.2	70.5	97.7
Fat (%)	0.11	1.28	2.45
Carbohydrate (%)	10.40	12.42	14.44
Protein (%)	0.16	2.32	4.49

[1)]Formulation of the samples (w/w): AS: 12%AS; AS-6SF: 12%AS+6%SF; AS-12SF: 12%AS+12%SF.
* Comply with South Korean Food labelling Standards for "source of protein" claim where the food contents more than 5% of the Nutrient reference for one day per 100 kcal. The Nutrient reference for Korean is 50g and 45g for male and female older than 65 years old, respectively.
§ Comply with South Korean Food labelling Standards for "high in protein" claim for female older than 65 years old where the food contents more than 10% of the Nutrient reference for one day per 100 kcal.

Textural and structural properties

Soy flour resulted in less rigid starch gel structure (Figure 2). It also reduced the hardness, cohesiveness, springiness and gumminess of the acorn starch gel (Figure 3). Food with lower hardness is suggested for the elderly for safety reasons [5]. All the samples fell into the ideal hardness for "stage 1" elderlies and dysphagia patients suggested by Japanese Care Food Conference [13].

The decreased gumminess indicates the lower energy required to disintegrate a semi-solid food product to a state ready for swallowing, which agree with the results of mastication test (Figure 5).

The hardness of AS gel increased drastically between day 1 and day 7 and the rate slowed down between day 7 and day 14. On the oth-

er hand, the hardness of AS-6SF gel and AS-12SF gel only changed slightly (Figure 4). The rather smaller change in hardness of AS-SF gels during storage might result from the protein-starch interactions [14].

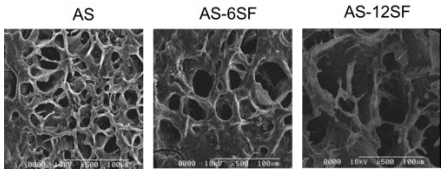

Figure 2 The morphology of the AS, AS-6SF and AS-12SF gels.

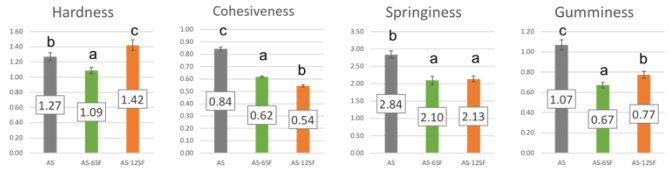

Figure 3 Masticatory properties of the gels in young and old subjects

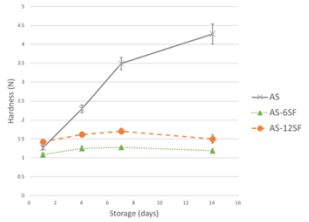

Figure 4 The hardness of the AS and AS-SF gels during storage at 4℃

Masticatory properties

Tongue plays an important role in mastication and tongue pressure is a useful masticatory parameter [5]. The old panel had lower tongue strength (533.6±164.8 hPas) than the young one (408.4±75.8 hPas, $p<0.05$). The results implied that the old group has lower masticatory efficiency. For the elderly group, the AS-SF gels had lower number of cycles and mastication time compared with AS gel (Figure 5). In other words, the addition of SF reduced the chewing efforts, which was an ideal characteristic for elderly foods [5].

The bolus particles size distribution shows the dynamic break down of the food during oral processing. The bolus particles were smaller after more chews, regardless the subject ages and samples. The results also showed that the higher the soy flour content, the smaller the bolus particles (Figure 6).

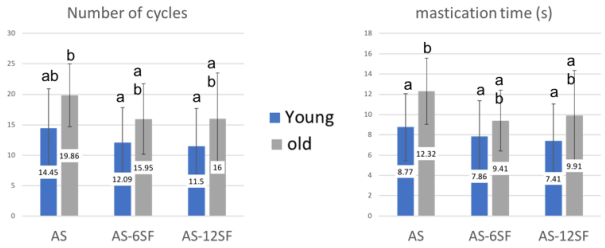

Figure 5 Texture properties of the gels

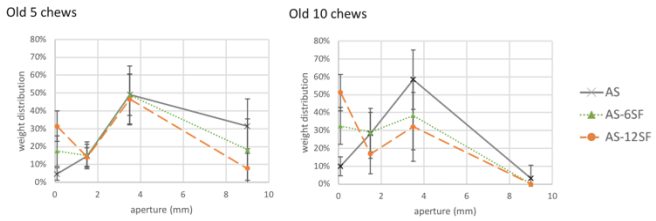

Figure 6 Food bolus particle size distribution

Sensorial properties

Springiness, taste and acceptability showed similar trend: AS gel had the highest score and AS-12SF gel had the lowest, though not significant different from AS-6SF gel. Cohesiveness was the highest for AS gel. AS gel had the highest score on appearance and hardness, but there was no significant difference.

The tastes of AS-SF gels were significantly different from that of AS gel. The higher the SF content, the lower the score. The correlation coefficients for the sensory parameters shows that the acceptability highly corelate to taste (0.902). Thus, the acceptability of the acorn jelly fortified with soy flour can be expected to score higher by improving the taste.

Conclusions

The textural and masticatory properties and sensory evaluation of the acorn starch gel with different levels of additional soy flour as protein-fortified traditional Korean dish for

the elderly were studied.

Soy flour affected the starch gel network, resulting a less dense structure and significantly decreased hardness, cohesiveness, springiness and gumminess of the scorn starch gel.

For the masticatory properties, the elderly needed longer mastication time and number of chewing cycles to prepare the ready-for-swallowing bolus and the therefore lower masticatory efficiency compared to the young adults. The addition of the soy flour decreased the mastication time and number of cycles in both age group.

The sensory evaluation showed that the soy flour decreased the acceptability and likingness of the other attributes of acorn starch gel. However, a higher acceptability of the protein-fortified acorn jelly can be expected when served with dressing as in a common Korean dish.

To sum up, the acorn starch jelly prepared with soy flour is “source of protein” food that have higher nutrient value and requests less chewing effort compared to the original form. Thus, it has the potential to be developed into food products for the Korean elderly consumers.

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Identification of Maillard-type Taste enhancers within a food matrix

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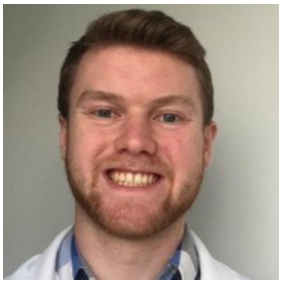

Introduction

Pyridinium compounds are a subclass of molecules generated thermally via the Maillard reaction (MR) and contain the cation $[C_5H_5NH]^+$. In literature, a series of pyridinium compounds have been termed "Taste Active" or having "Tastant" activity. This means that their presence in trace amounts decreases the threshold of activation for sweet, salty, and umami taste receptors on the tongue despite being tasteless on their own (Hillmann et al., 2016). In this thesis, the tastant molecule pyridinium 1-(1-carboxyethyl)- 5-hydroxy-2-(hydroxymethyl)-pyridinium inner salt or commonly termed alapyridaine, was investigated. Alapyridaine was shown to form in binary model systems of heated amino amino acids and reducing sugars (Ottinger et al., 2003). The specific taste enhancement ability is related to the moiety of 2-(hydroxymethyl)-5-hydroxypyridinium. Alapyridaine has not shown an effect on altering sour or bitterness sensations (Dunkel et al., 2007). By the addition of MR precursors, how pyridinium compounds form and degrade through the MR can lead to methods of detection and technological processes which can optimize the formation of taste active molecules in real food matrices.

Research objectives

1. Investigate kinetic formation of taste active alapyridaine & similar pryridinium MR molecules in several biscuit model systems
2. Propose a novel strategy to promote the formation of taste active molecules in biscuits

Methodology

Biscuits were prepared as is standardized by the American association of Cereal Chemists (AACC) procedure 10-54 with some slight adjustments per recipe whose variance from the control recipe is documented in Table 1.

Post-preparation, biscuits were lyophilized (-20˚C) overnight then blended into a fine powder and stored (4˚C). To identify instrumental parameters for identifying tastant molecules,

Table 1 Biscuits prepared using following ingredients in all recipes unless noted in Table 1: wheat flour 40g; sucrose 29.5g; glucose 4.5g; palm oil 10g; deionized water 8.8g; sodium bicarbonate 0.4g; ammonium bicarbonate 0.2g; sodium chloride; 1.0g.

	Amount in Dough (g)			
Biscuit Recipe	**Ala**	**Sucrose**	**Glucose**	**Honey**
Alanine	0.06			
Control+ Honey		29.39	0.0	12.6
Alanine+ Honey	0.06	29.39	0.0	12.6

an equimolar, thermally treated alaine:glucose model was analysed according to the procedure found in Wakamatsu et al. 2016. Tastant extraction was conducted by adding 3ml 80/20 (v/v) Water:Methanol to 0.5g aliquot biscuit sample, vortexing (10m), centrifugation (5m), repeating twice, collecting the 9mL supernatant, drying 3mL via evapocenterfuge (4hr) and rehydrating with 1mL 80/20 Water:Methanol. 20 µl of filtered (0.45nm PTFE) sample was injected onto the chromatographic column. Pyridinium compounds were detected with a Synergi Fusion (100 x 2.0 mm, 4 µm, Phenomenex) column, amino acid and amadori compounds zwitterionic modified HILIC column for High Resolution Mass Spectrometry (HRMS) analysis.

Results and discussion

Upon the addition of alanine to the biscuit food matrix, alapyridaine is clearly formed as seen in Figure 1 and degrades as cooking time increases. The highest concentration of alapyridaine was seen within the alanine bis-

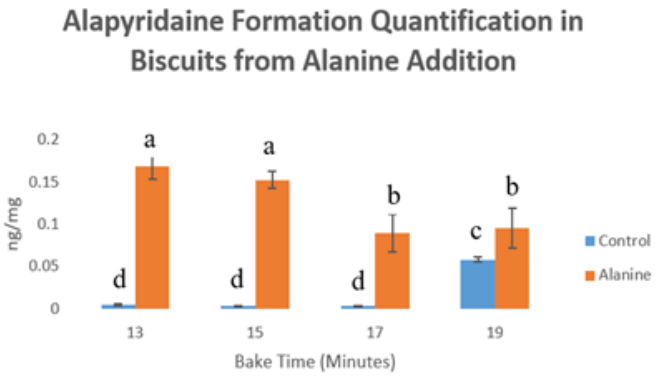

Figure 1 Different letters indicate significant differences between amounts detected between groups via ANOVA & t-test.

cuits was 17 ng/mg biscuit at 13 min.

The control biscuit does not show a detectable amount of the compound until min 19 when it reaches the concentration of 0.05 ng/mg biscuit sample.

Alapyridaine forms at an increased rate between 13 and 19 min for the honey biscuits, and increases in ng/mg despite the addition of alanine. The control honey biscuit however, shows the formation of alapyridaine is in

a less subnational manor than the honey biscuit with alanine.

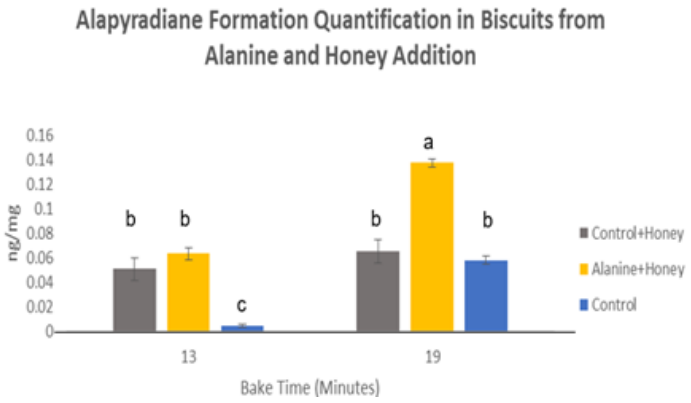

Figure 2 Different letters indicate significant differences between amounts detected be-

P2, another pyridinium compound similar to alapyridaine was detected in the biscuits with the alanine addition, however it was not found in the control biscuits. Similarly to alapyridaine,

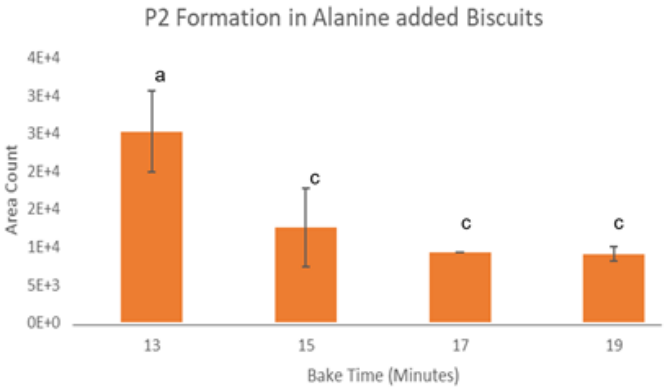

Figure 3 Different letters indicate significant differences between amounts detected between groups via ANOVA & t-test

P2 is also degraded over time through the reaction from 13 min where the highest amount was observed.

P4, another pyridinium compound similar to alapyridaine with potential tastant activity was detected as seen in figure 4. P4 formation is minimal in the control biscuit until 19 min while the alanine biscuit shows an exponential-

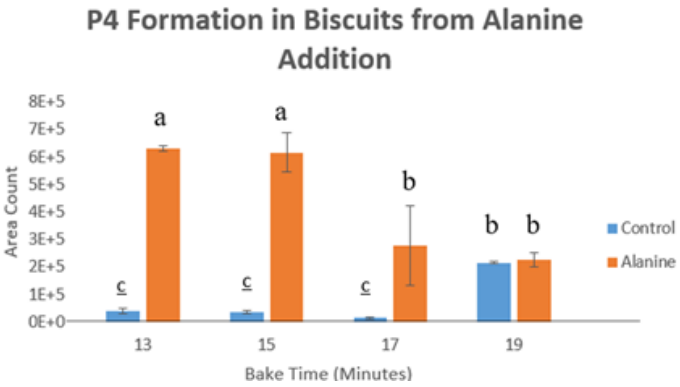

Figure 4 Different letters indicate significant differences between amounts detected between groups

ly higher amount of area count comparison at 13 and 15 min then degrades at 17 and 19 min to almost half of the formation seen at 13 minutes.

Unlike the previous alapyridaine and P2 compounds which degrade after 13 mins, P4 seems to continue formation after 13 min in both experimental biscuits. The alanine+honey biscuits continued to form at a

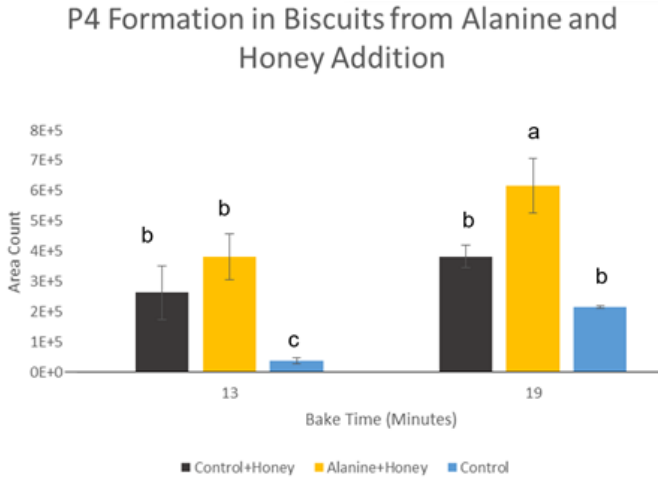

Figure 5 Different letters indicate significant differences between amounts detected between groups via ANOVA & t-test

higher amount than the control biscuits for P4 detection. A tendency for a higher concentration of P4 in alanine+honey biscuit vs control biscuit was observed at 19 min.

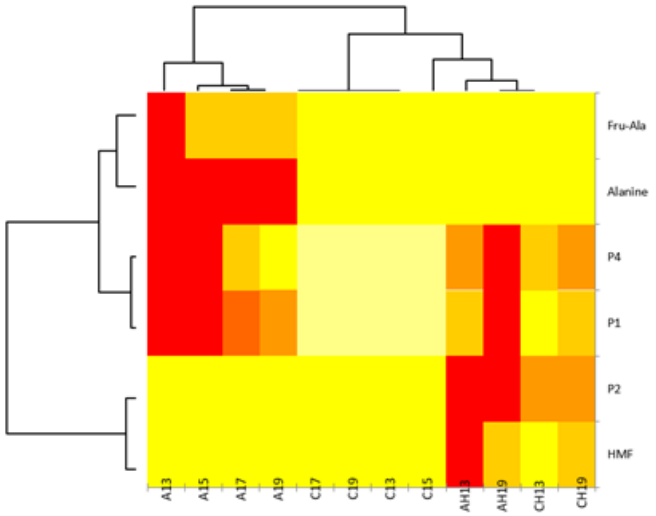

Figure 6 Heat map & clustered hierarchical data of total biscuit experiments and compounds detected. Color range from lowest observed in white/yellow to highest in dark red used area counts, followed by centering and reduction procedure based on Ward's method in order to keep under control different ionizations of the samples and their calibration curves. Statistically observed groups are seen on the top and left x and y axis periphery.

Conclusion

The addition of alanine in a biscuit food matrix, confirmed the formation of taste active molecule alapyridaine and two additional pyridinium compounds at faster rate than a similarly formulated control biscuit due to the presence of their key precursor, alanine. Control biscuits did show similar formations at 19 min, but practically this would be far too burned for the ideal taste altering sensory characteristics to take effect. As a typical source of free amino acids, reducing sugars and other functional molecules, the addition of honey in the biscuits formulation also increased the rate at which alapyridaine was formed due to the additional MR precursors found in the honey such as the amino acids alanine and reducing sugars. For P2, its formation was interesting in that it was only detected in the alanine addition biscuits and then degraded over time. P4 in the alanine biscuits followed a similar degradation pathway but in the honey biscuits did the opposite and continued to form kinetically from 13 to 19 min. Further research on these types of tastant molecules could lead to the development of foods which could modulate taste thresholds and maintain a healthier nutritional profile by creating more desirable low fat, sugar, and salt products.

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Prevalence, drivers and practices of Infant Formula and Breast Milk Feeding from 31 countries and a case study in Singapore

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Several studies have focused on infant feeding methods. Mixed milk feeding (MMF), the combination feeding of infant formula and breast milk, has not been studied in a consistent way yet. This study aimed to identify the prevalence and main drivers and practices of MMF described in the literature and in a clinical study. To this purpose, a systematic literature review about the various modes of infant feeding was performed. Additionally, unpublished data obtained from a prospective clinical study performed in Singapore which started in 2011 were analysed, as to the prevalence, duration and starting date of breast- and formula feeding. This study was the first one to collate worldwide data on MMF on prevalence, drivers and practices.

Confidential topic

Paper-based flexible laminates tendency to curl

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Introduction

Flexible packages have started replacing traditional containers. Between 2012 and 2017, the volume of food and beverage flexible packages actually increased by 11% in the world as opposed to 5% for the global packaging industry growth (Euromonitor International, 2018). Flexible packaging is all the more interesting that it enables creative eye-catching designs which generate high market appeal, lower shipping and storage costs (smaller and lighter packages) as well as a lower environmental impact (fewer resources and less energy for production, lower transport-related CO_2 emissions and convenient features which may help reduce food waste) (Lingle, 2012; Hrinya, 2017).

Within this category, flexible multi-layer constructions - also called laminates - can be designed to meet specific performance requirements. Each layer indeed provides the multi-ply packaging material with a particular function or particular functions such as gas barrier, moisture barrier, light barrier, chemical resistance, puncture resistance, strength and heat sealing ability (Hrinya, 2017). Paper materials can namely be laminated: they are often selected for their stiffness and dead-fold properties (i.e. once folded, the material retains its shape and does not unfold - Riley A., 2012) as well as their environmentally-friendly appearance.

However, paper-based packaging materials

are well-known for causing important issues during converting and filling processes due to paper hygroinstability (i.e. dimensional change due to fluctuations of the surrounding atmosphere moisture - Lindner, 2018). Curl phenomenon is a common problem which may happen in non-climatized manufacturing facilities. It can be defined as "an undesirable condition caused by uneven rates of absorption or evaporation of moisture, uneven rates of contraction or expansion, or internal stresses in the material" (Catty Corporation, 2017).

The purpose of this master thesis was to describe and assess the effect of climate conditions on paper-based flexible laminates tendency to curl so as to understand to what extent environmental conditions can affect their processability. It was suggested by and conducted for the German multinational food company *Unternehmensgruppe Theo Müller* - the sixteenth biggest milk processor in the world in 2016 (Cornall, 2016).

Research objectives

1. Identify the main factors leading to paper-based flexible laminates curl phenomenon (namely environmental conditions);
2. Study the behaviour of two different paper-based flexible laminates under varying relative humidity (RH) and temperature conditions;
3. Assess climate-related risk for both materials;
4. Test the effect of low-density polyethylene wrapping (abbreviated to PE wrapping) as a solution to prevent or reduce packaging materials tendency to curl.

Materials and methods

Two different laminates were considered:

- a widely processed 60-µm thick heat-sealable yogurt lid made up of paper and metalized polyethylene terephthalate, coated with a heat seal lacquer (Pap/mPET/HSL);
- a 67-µm thick prototype laminate made up of aluminium foil, paper and polyethylene film (Alu/Pap/PE).

Considering the very few packaging materials rolls which were made available as well as their dimensions (a single 106-mm diameter test roll for the Alu/Pap/PE prototype laminate), it was decided to sample materials sheets from rolls.

The cross-cut method was selected as test method for the determination of the tendency to curl (Deutsches Institut für Normung (DIN), 2014). On the whole, it consists in cutting crosses in the packaging material web using a given cutting pattern and measuring specific distances, in the machine direction (MD) (= a parameter in mm) and the cross-machine direction (CD) (= b parameter in mm) (see Figure 1).

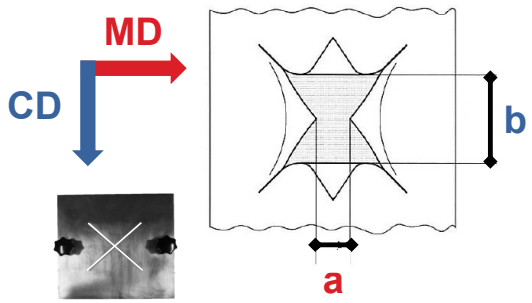

Figure 1. The cross-cut method (adapted from Deutsches Institut für Normung (DIN), 2014).

Laminates tendency to curl was assessed under fifteen climates i.e. under five RH values (30%, 40%, 50%, 60% and 70%) and three temperature values (20°C, 25°C and 30°C), which were defined based on RH and temperature data recorded within a factory and documented by the quality team.

Results and discussion

Main factors leading to paper-based flexible laminates curl

Numerous factors can lead to paper-based flexible laminates curl, at different levels (cellulose, paper, laminate, roll) and different stages (converting, warehousing, filling). RH and temperature happened to be the most well-documented factors. However, this does not mean that they are the most significant ones since no hierarchy has been described yet. There is currently a lack of information as regard to paper-based flexible laminates curl phenomenon.

Impact of relative humidity and temperature on the two studied laminates behaviour (Figure 2 and Figure 3)

Concerning the Pap/mPET/HSL laminate, deformation occurred both in the MD and the CD: average curl values respectively met 13 mm and 37 mm. RH and temperature were both shown to have a significant effect on its tendency to curl; RH more significantly impacted its tendency to curl than temperature. Highest curl average values were reached for 50% and 60% RH whereas lowest ones were reached for 30% and 70% RH. The material was demonstrated to be sensitive to climate conditions.

Concerning the Alu/Pap/PE prototype, deformation only occurred in the MD: the average curl value met 3 mm. Whatever the environmental conditions, the CD-oriented curl parameter was always equal to 0 mm. On whole, the laminate tendency to curl was shown to be low and not sensitive to climate conditions.

Materials climate-related risk assessment

The Pap/mPET/HSL laminate climate-related risk was characterized as high. It was namely possible to observe and describe paper fibres hygroexpansion in the MD and the CD under various RH. Considering the given laminate

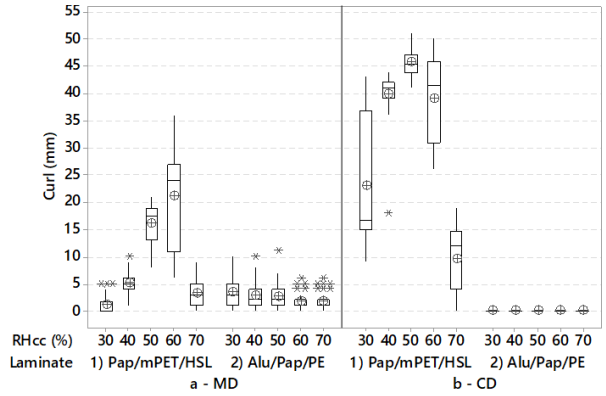

Figure 2. Boxplot comparing the RH effect on the studied laminates tendency to curl.

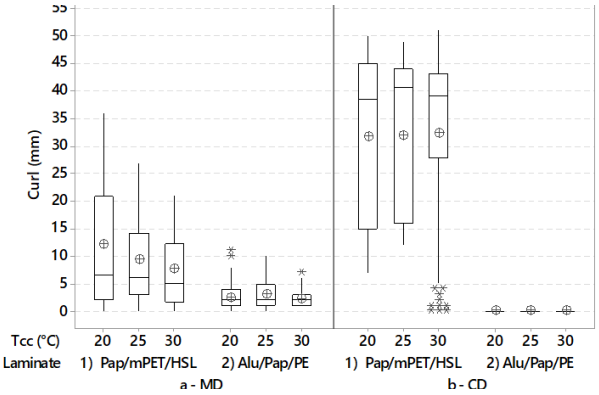

Figure 3. Boxplot comparing the temperature effect on the studied laminates tendency to curl.

structure, paper may directly exchange water with the environment (no barrier).

The Alu/Pap/PE prototype laminate climate-related risk was characterized as low. Considering the given laminate structure, paper is sandwiched between aluminium and PE which probably protect it .

Solution to reduce paper-based laminates tendency to curl (Figure 4)

In the case of the Pap/mPET/HSL laminate, PE wrapping led to a stronger tendency to curl (while limiting absolute variations in curl) and was therefore not considered as protective.

In the case of the Alu/Pap/PE laminate, PE wrapping led to lower curl averages in the MD (while enabling relatively high absolute variations in curl) and was thus considered

as protective. These opposite observations made the PE wrapping effect complex to analyse. Considering the given material-specific results, it was not possible to draw a single general conclusion for all the paper-based flexible laminates.

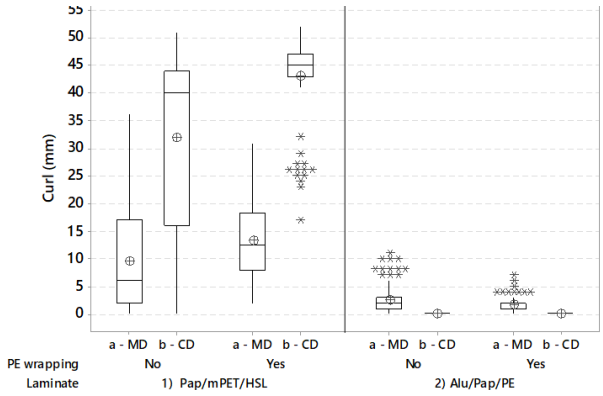

Figure 4. Boxplot comparing the effect of PE wrapping on the two studied laminates tendency to curl.

Conclusions

Recommendations usually made to avoid paper-based packaging materials curl phenomenon were shown not to be applicable to paper-based laminates. Indeed, RH and temperature ranges (45-60% RH and 20-25˚C) recommended by paper suppliers did not appear particularly meaningful. Considering the given material-specific results, laminates behaviour may depend on the different materials which are bound together and should not be boiled down to the behaviour of one single material. Consequently, this kind of study should be conducted to assess RH and temperature effects on the tendency to curl of any single laminate (no possible extrapolation from one material to another).

Further research recommendations

This thesis investigated the effect of humidity and temperature as regard to paper-based flexible laminates tendency to curl. Two main research areas were finally suggested. Firstly, conducting a similar study at the roll scale (as opposed to the sheet scale) which would probably be more meaningful from the industry perspective. Differences in curl might indeed be expected depending on the location of the samples towards the roll core. Secondly, undertaking a study comparing the effect of the lamination process nature to the one of the environmental conditions on paper-based flexible laminates tendency to curl. Changing the lamination process could indeed reduce the tendency to curl much more than trying to protect packaging materials from "harmful" environmental conditions. The idea behind would be to hierarchize the different factors leading to curl so as to define effective solutions to this problem.

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Upstream innovation and discovery in the field of enzymes and protein hydrolysates for the early life nutrition portfolio

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Human milk is regarded as the best nutrition for infants. However, when breastfeeding is not possible, infant formula(IF) serve as an adequate substitute for human milk. Infant formula is a form of specialty nutrition with highly-balanced composition aimed at mimicking breast milk, the golden standard, as closely as possible. The infant formula industry nowadays offers a wide range of products trying to fulfil the changing needs of newborns and young children in early stages of life. These formulas have been designed to provide infants with the required nutrients for optimal growth and development. In addition, the composition of infant formula has evolved over the last decades based on increasing insights and technological developments.

The study involved application of bioprocessing aids as novel approach to finding solutions to renovate and innovate IFs. Research study focused on multiple projects involved in upstream innovation for applications in ELN product portfolio.

Confidential Topic

Integration of Transparency into Packaging Design

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Introduction

Transparency has become a key sales pitch for companies! It enables them to show their product and tell the consumers they do not have nothing to hide: more and more consumers want to see the products they are buying. In a study made by Simmonds et al (2018), more than half of consumers interviewed believed that it is important to be able to see the product through transparent packaging, But from a technical point of view, transparency implies many risks for product's quality such as photooxidation and other reactions leading to colour changes, off-flavours and decrease of product's quality (Frederiksen, Haugaard, Poll, & Becker, 2003). Therefore, the purpose of this master thesis, conducted within the French company Danone, was to study the impact of transparency on the sensitive molecules present in fermented animal and vegetal milks and fermented cow milk mixed with fruit preparations. The final aim was to propose packaging solutions and to provide design guidelines to integrate transparency into Danone's packaging

Research objectives

The research objectives of this master thesis were :

1. To review the current light test protocol used in Danone and define a new one to better evaluate the impact of light and oxygen on fermented products

2. to understand the impact of light, coupled with oxygen, on two types of products
3. to define for each kind of product studied the barriers needed into the packaging and provide packaging design guidelines.

Methodology

The overall methodology used is summed up in the following figure:

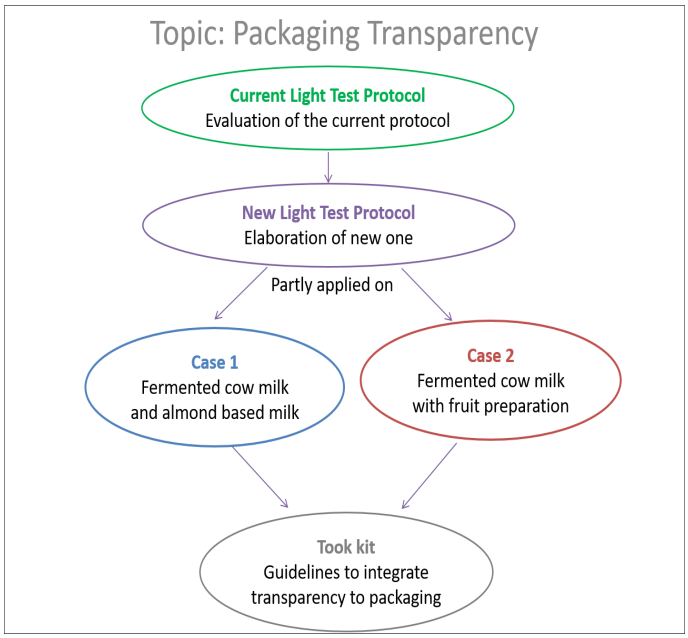


Figure 1. Overall methodology procedure

In order to evaluate the current light test protocol in Danone and elaborate a new one, a comparison was done with what was found in real supermarkets and in other Danone centres. Part of the new light test protocol was then applied in two cases presenting four products and different packaging barriers :

- Case 1 studies two types of fermented milks: one fermented cow milk and one fermented almond-based milk. PP + EVOH and PP + EVOH + UV-block were tested on these products, with and without headspace.
- Case 2 is giving input on a fermented cow milk mixed with fruit and vegetable preparation. One red preparation and one green preparation were studied. PP + EVOH + UV-block and HDPE + UV-block were tested on these products.

For each case study, products were placed during five days under alternative fluorescent lighting (14h on/10h off) at 6°C ± 2°C, and then stored until end of shelf life + 30% in the dark. Some samples were kept in the dark during the whole test and served as reference. At three milestones (just after light exposure, at the end of shelf life and at the end of shelf life + 30%), several measurements were conducted to assess the impact of light and oxygen on fermented products: an organoleptic evaluation, a gas chromatography, pH and Dornic degree measurements, colorimetry and gas analysis in headspace.

Results and discussion

Light Test Protocol

Based on the current protocol and the observations made in supermarkets, a new protocol was established to evaluate the impact of light and oxygen in supermarkets. First, both fluorescent and LED lights are now proposed in the protocol, taking into consideration the huge increase of LED technology, which does not emit UV wavelengths. Furthermore, two different purposes were given for this test: the first purpose is to “understand”, at early stages of the project, the impact of light on the product packed in primary packaging, by testing different barriers, to give recommendations to the packaging developer. The second one is to “validate” the final packaging, including secondary, to check at later stages of the project, if light has or not an impact on the product. In order to make these evaluations, the protocol also suggests different analytical tests to support the organoleptic evaluation and explain what is observed in order to give guidelines.

Case 1—Fermented cow and plant-based milks

The general results for case 1 products are summed up in Table 1.

Table 1. General results for fermented cow and plant-based milk.

Test	Dairy and Plant-based Milks
Sensory test	
Gas Chromatography	
O_2 content in headspace	
pH	
Dornic Degree	
Colour	

Differences were observed between samples exposed to light and samples stored in the dark regarding organoleptic properties and gas chromatography. « Old cheese » and rancid off-notes were detected in the samples exposed to light, and can be correlated with two types of molecules observed in gas chromatography profile : sulfuric compounds coming from the oxidation of proteins (Decker, Elias, & McClements, 2010) and unsaturated aldehydes coming from the oxidation of aldehydes (Mestdagh, 2005). Removing the headspace improved the organolpetic properties of both dairy and plant-based products, which was also confirmed by the gas chromatography. However, the UV block did not help preventing from photo-oxidation, which reinforces the hypothesis in dairy that porphyrins and chlorophylls excitation is more linked to sensory properties than photooxidation triggered by riboflavin (Wold, et al., 2005).

Case 2—Fermented cow milk mixed with fruit and vegetable preparation

One specificity of these products is their ferment: this last one reacts with malic acid naturally present in fruits and produces CO_2. Gas barrier properties of the packaging was therefore much more important than light impact. Table 2 summary the observations made in this case.

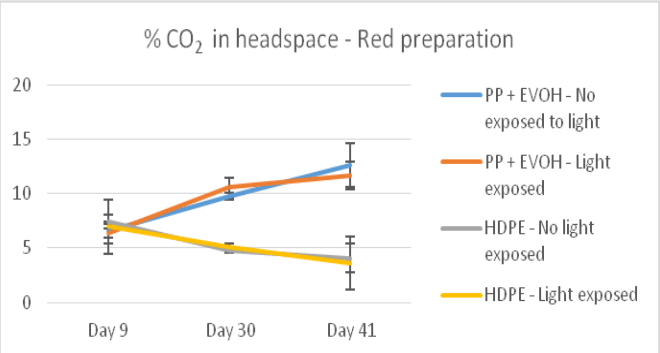
Table 2. General results for fermented cow mixed with fruit and vegetable preparation

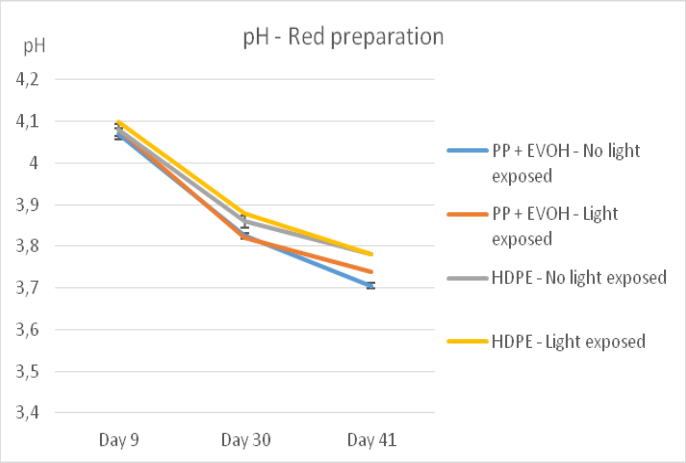
Test	Fermented milk with fruit preparation
Sensory test	
O_2 content in headspace	
pH	
Colour	

Test	Fermented milk with fruit preparation
Sensory test	O_2
O_2 content in headspace	O_2
pH	O_2
Colour	O_2

No differences were observed between samples exposed to light and stored in the dark. However, both red and green samples packed in PP + EVOH + UV-block, very barrier to gas, were felt much more acidic than the ones packed in HDPE + UV-block. This can be explained by the big increase of CO_2 coming from malic acid fermentation (see Graph 1), which cannot escape from the bottle and is dissolved in the product, provoking an acidification (see Graph 2). This huge acidification may have hidden the impact of light on the products, meaning that no clear conclusion about light impact can be made.

Graph 1. CO_2 content evolution in headspace for fermented cow milk with red fruit preparation





Graph 2. pH evolution in fermented cow milk with red fruit preparation

Finally, in red products, colour was also impacted by the barrier properties of the packaging. The hue is the parameter changing between packaging options: samples packed with an oxygen barrier resulted in having more yellow hue than the ones without.

Conclusions

Light has shown to have impact on fermented dairy and plant-based milks, regarding sensory properties. Removing the headspace helped protect the product: therefore a packaging with gas barrier and nitrogen flush is recommended for these products. Moreover, blocking UV does not seem to prevent from photo-oxidation: therefore it is not compulsory to add one, meaning more recyclability and less cost. Finally, full transparency does not seem reachable for these products: even without headspace, some off-notes were still detected. A sleeve, some decorations or a pick-up may be needed.

Regarding fermented milk with fruit and vegetable preparation, gas barrier was a very important asset. A packaging which lets CO_2 escape is necessary, to prevent from lid bombing and acidification. A reduction in malic acid in the product would also be a solution to reduce this effect.

Finally, an important conclusion of this thesis is the protocol which should be followed when evaluating the impact of light on products : coupling analytical tests with sensory evaluation is mandatory in order to be able to explain the mechanisms occuring in the product and to give design recommendations.

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Rapid Sensory Method to Optimize a Novel Savory Snack with Cricket Powder

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Introduction

In many regions of the world, mainly in Africa, Asia, and Latin America, consuming insects as a food source is very common (Jongema, 2015). On the other hand, in most Western countries an opposite situation occurs. As the food-related concerns, and socio-cultural norms still against the acceptance of insects as food (Lensvelt & Steenbekkers, 2014).

During the past few years, the consumption of insects has been significantly increasing. Accordingly, insects are particularly considered as a meat substitute due to their high protein content (Megido et al., 2016) and can be more sustainably produced than traditional livestock (DeFoliart, 1992; van Huis, 2013). However, in the Western culture, consuming whole insects is still uncommon. Therefore, incorporated processed insects into regular food reported a higher willingness to eat (Hartmann et al., 2015). For instance, developing food products close to the Western food pattern such as bakery products with insect flour. Savory insect products are perceived to be more appreciated than sweet products (Tan, van den Berg, & Stieger, 2016) according to the meat alternative position (Shelomi, 2015; Tan et al., 2015).

Insects demonstrate to be an exceptionally good source of protein (Ramos-Elorduy et al., 1997) and also a great source of fat (Womeni et al., 2009). Moreover, insects contain high fiber content, commonly in chitin form (Van Huis et al., 2013), and have

higher energy content, as well as sodium and saturated fat, comparing to the traditional livestock. Meanwhile, insects tend to have very high micronutrient content than conventional meats. Especially, calcium, iron, vitamin C, vitamin A and riboflavin (Payne et al., 2016).

In January 2018, the new EU regulation on novel foods went into effect. Even though edible insects could be classified as "Novel Food" and the new EU regulation is applicable, currently no insects or their derivatives are authorized for human consumption in Italy. To be commercialized as food in the Italian market, the insect-based products must be authorized from European Commission, following EFSA guidelines (ANSA, 2018).

Aims

The main purpose of this thesis was to develop and optimize a new cricket-based savory snack using rapid sensory methods. The cricket-based product chosen was an Italian bakery called "tarallo" - a typical savory snack in Southern Italy ("taralli" is plural).

Materials and methods

Wheat flour (50-58%), cricket powder (2-10%) and water (20-28%) were chosen to be the independent variables in the mixture experiment with a total fix proportion of 84%. Other ingredients were olive oil (14.5%), salt (1.3%) and black pepper (0.2%), respectively. Eight formulas of cricket-based *taralli* were generated by Design-Expert® (Table 01). Formulation 5 and 7 were used as blind replicated formulations in the sensory evaluation.

Table 1. Experimental Formulation

Formulation/100g	Wheat flour (g)	Cricket powder (g)	Water (g)
1	50	6	28
2	50	10	24
3	54	2	28
4	54	10	20
5	58	2	24
6	58	6	20
7	54	6	24
8	50	8	26

Fig. 1. *taralli* with cricket powder. The position of the formulations from left to right: (Top) 1,2,3,4; (Bottom) 5,6,7,8

Physicochemical properties, such as color, moisture content, water activity and texture, were measured in order to evaluate the quality of taralli and the reproducibility of the production batches.

The innovated Flash Profile procedure as proposed by Liu et al. (2016) was used in this thesis. This involved the combination of the Napping procedure method and attribute reduction and definition in the Flash Profile method. 15 judges participated in the sensory evaluation.

They performed first a Napping procedure to individually generate their own sensory attributes. In a second session, they compared their own lists with the global list and finally selected the sensory attributes (maximum 10) that able to discriminate among the samples. The third and fourth sessions consisted of two repetitions of Flash Profile for ranking samples. They were asked to evaluate the

sample set and rank the samples from low to high intensity.

The Design-Expert® software was used for the formula optimization. In order to optimize the ideal formulation, the desirability function was used and the ideal scores for each attribute were set to be targets to create the optimal condition (Nath & Chattopadhyay, 2007).

Results and discussion

Physicochemical Properties

The color of *taralli* seems to be mainly affected by the concentration of cricket powder. But the cooking procedures variability could affect also the color. Generally, tarallo is a low moisture food containing 7-8% water (Marquez et al., 2014). However, the moisture content of *taralli* samples containing cricket powder are quite low (1.9-6 %RH). Likewise, the water activity (aw 0.1-0.5) results also correspond with the moisture content. Hardness (16-38 N) are higher than *taralli* available in the Italian market which were range of 11 to 21 N (Barbieri et al., 2018).

Sensory Evaluation

Napping® session helps judges become familiarized with the sample space, according to the positioning tasks in order to improve discriminability, repeatability and accuracy before continuing with Flash Profile evaluation. The judges were asked to generate their own attributes individually that also subsequently used in Flash Profile.

The Flash Profiling of *taralli* with cricket powder gave the positioning of the samples as shown in Fig. 2. The graph shows a good repetition results for the formulations 7 and 5.

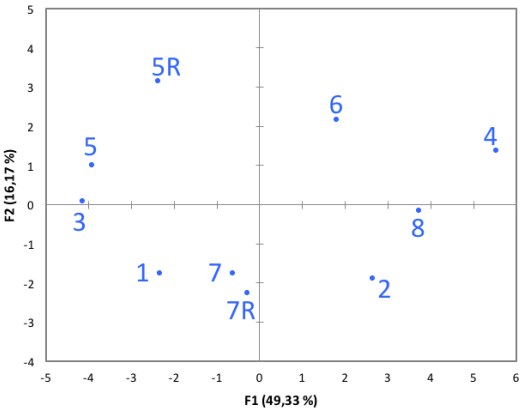

Fig. 2. Consensus plot of *taralli* with cricket powder in Flash Profile

In Fig. 3., this graph is the correlation plot of individual sensory attributes used to evaluate the samples in Flash Profile. Physicochemical properties and ingredients were used as supplementary data. According to their performance, the judges that were not able to discriminate well or placed the repeated formulations far from each other were eliminated from the data set, then we used only the data from 12 out of 15 judges.

Attributes such as “Hard”, “Stale”, “Grainy” is positively related to Water. And also, positively related to RH, aw and hardness. While attributes such as “Overall flavor” and “Salty”, is positively related to wheat flour. The trend of most attributes display near the cricket powder. Such as “Brown color”, “Dark color”, “Burned taste”, “Intense odor” that often found together. As well as “Spicy” and “Friable”. Therefore, this represents a high correlation between cricket powder and those attributes. The attributes “Crispy” shows non-uniform position, so it did not take into consideration.

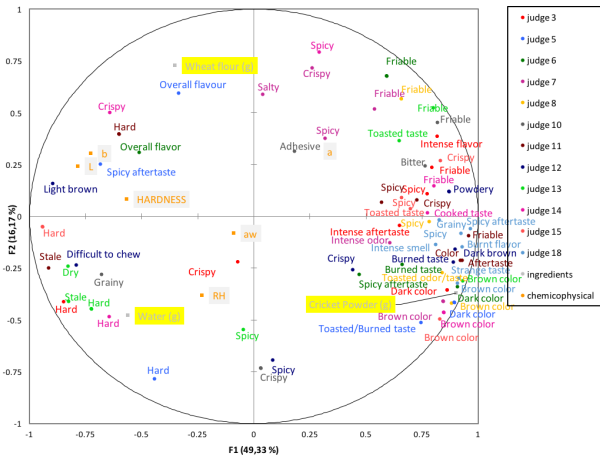

Fig. 3. Correlation plot of sensory attributes. *Physico-chemical data and ingredients were used as supplementary variables*

Formula Optimization

In order to find the ideal formulation, 5 attributes from Flash Profile session were chosen from the list according to position of attributes in Fig. 03 and the performance and frequency of use by judges to perform the analysis by Design-Expert® software. They were "Spicy", "Friable", "Brown color", "Hard" and "Burned taste".

The contour graph, as shown in Fig. 4., represents a plot of the attribute as a function of the three mixture components. The maximum constraint of each ingredient is indicated at each vertex. Red color represents the maximum intensity while blue color represents the minimum intensity. All the attributes, especially brown color, increase linearly with cricket powder concentration with exception for hardness. It was fitted by a special cubic model. In particular, when combine the effect of components together, for example, cricket powder with wheat flour, they show a negative correlation to the hardness.

The criteria for ideal formulation were set for the optimization step (Table 2). The highest desirability indicates the formulation that gives the best % components to obtain the ideal attributes level (range from 0 to 1). According to the desirability contour graph in Fig. 04, the graph showing graduated color which cool blue indicated for lower desirability and warm yellow for higher desirability. The flag was set at the optimal point of the solution. As a result, the solution with 56% of wheat flour, 22% of water and 6% of cricket powder that has the desirability value of 0.74 is the best option.

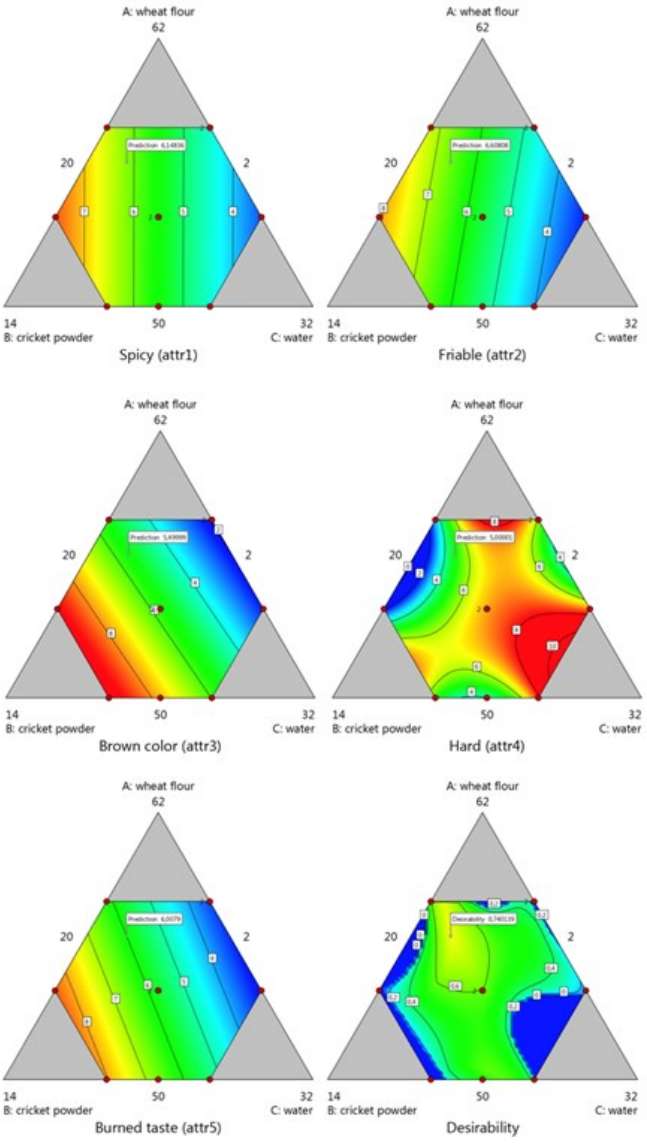

fig. 4. The contour graphs show the relationship between the ingredients and the response attributes of taralli.

Table 2. The criteria for ideal formulation

Attributes	Criteria
Spicy	6
Friable	7
Brown color	5.5
Hard	5
Burned taste	6

Conclusions

Cricket powder is highly affect in the sensory properties of taralli. It shows the highest correlation with the response variables in both positive and negative way.

The used design was useful to optimize the formulation of taralli with cricket powder.

The validation of the ideal formulation is required in a further step. Thus, the optimized formulation of the *taralli* with cricket powder will be prepared and the sensory evaluation performed to verify the predicted responses.

The limitation of this thesis is no consumer acceptance testing. Because the permission to test the new product on a large scale was not received yet from the ethical commission.

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Development of an innovative liquid format of tailored nutrition for the first days of life

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Danone is currently working on the development of a new infant formula in liquid format for Tailored Nutrition. The company is looking to expand their liquid portfolio for this category of products. The aim of this project was to evaluate the technical feasibility of the new product category. Particularly, to evaluate the effect of different formulation/processing conditions in order to determine the conditions leading to a stable system.

Infant formulae were prepared at pilot plant scale using a standard recipe to which a specialty ingredient ("the ingredient") was added. The effect of different variables on the stability of the product were assessed, namely the ingredient's concentration, use of homogenization, and ultra-high heat treatment. The product was characterized by particle size analysis, microscopy, and some other analysis.

Based on the results obtained, a range of suitable concentrations of the ingredient and some processing conditions were identified. This study gave key insights on the approach to be taken for further development.

Confidential Topic

Critical factors for shelf life prediction of commercial fruit product

Siqi ZHANG carried out a join thesis with Jue SONG .

Please refer to page 70 to see her profile

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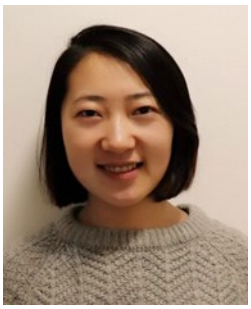

Introduction

According to the European Commission (2016), food waste in the EU is around 88 million tons per year, with an associated cost estimated to 143 billion euros. Wasting food is not only an economic and ethical issue because of the persistent high number of chronically undernourished people in the world, but also an environmental problem as the manufactures deplete limited natural resources and cause emissions into air, water and soil during production and along the supply chain (Manfredi et al., 2015). Most of the food waste can be avoided by acting on the food shelf life since one of the main reasons for throwing away food is not being used before its expiry date (WRAP, 2008). Few food producers are willing to risk their reputation on a food safety scandal since a product recall gives bad publicity and lowers the value of the brand. The commercial shelf life is often shorter than the technical (real) shelf life, adding to food waste.

Research objectives

- The effect of headspace volume and package volume on shelf life
- The correlation of vitamin C degradation and browning
- To identify critical factors that influence shelf life of fruit product

Methodology

The research methodology in this thesis includes three integrated parts (see Figure 1), two experimental parts and one regression analysis part.

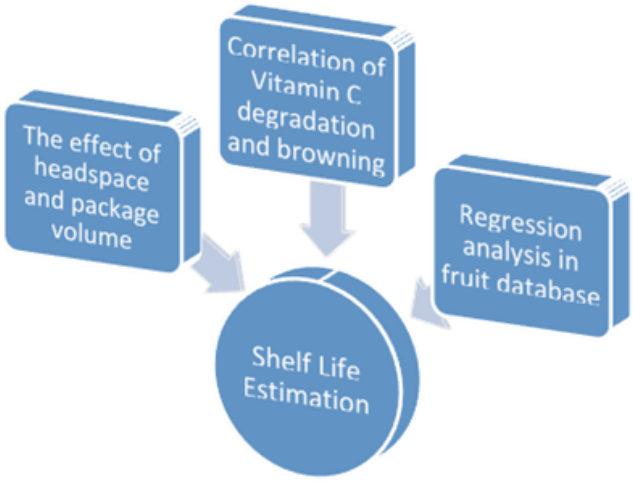

Figure 1. Overall approach

The first experimental part is to find out if the product in small package (Tetra Recart 200mL) has a different shelf life compared with the large package (Tetra Recart 390mL). The headspace volume and package volume of two packages are different, leading to the difference of oxygen content. Vitamin C was chosen to be the indicator of shelf life. The purpose of second experimental part is to identify if vitamin C concentration can be a predictor of browning which is the indicator of shelf life for processed fruit. Pineapple was chosen as sample because it is sensitive to browning. Storage tests under different temperatures with different package sizes and initial vitamin C concentrations were conducted. As for the regression analysis, primary reports were first extracted from Tetra Recart Food Database, then were sorted into different categories according to different projects. The factors investigated here were fruit category, vitamin C concentration, blanching temperature, storage temperature, heat treatment temperature and heat treatment time. Then stepwise regression and ordinal logistic regression were implemented to identify variables that have the main influence on shelf life. These three integrated parts all contribute to the shelf life estimation of fruit products in Tetra Recart packaging.

Results and discussion

The effect of headspace and package volume

Degradation rate of AA at each day is slightly higher in large package according to the slope shown in Figure 2.

Forecast based on the current data reveals that it will take about 349 days to consume all the AA in small package, while only 329 days in the large one. Higher oxygen transmission rate and larger surface between headspace and syrup can explain this.

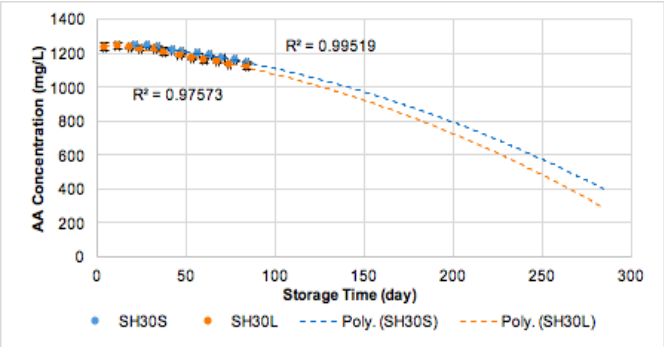

Figure 2. Changes of AA retention and forecast in two sizes of package

As shown in Figure 3, a good correlation between AA degradation and total oxygen consumption means all three origins of oxygen play an important role on the loss of AA. When the same amount of AA is degraded, less oxygen will be needed in large package, which means there is more anaerobic degradation happened at bottom of large package.

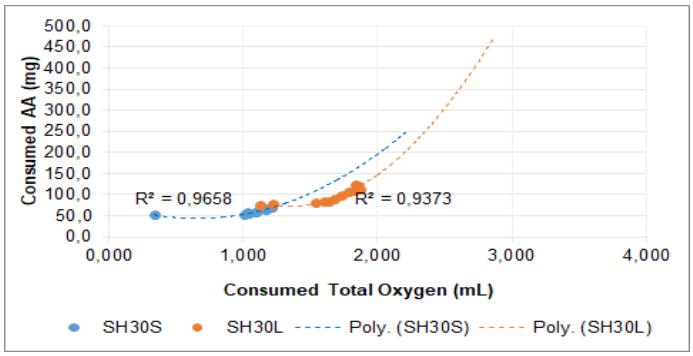

Figure 3. The effect of oxygen on AA degradation in two sizes of package

The correlation between vitamin C degradation and browning can be observed in pineapple product in PL30S when compared with the product in PH30S. For the products of low AA concentration, the *a* value increased faster than the ones of high concentration and the value was bigger than -3 at the 12th week (see Figure 4). As for the *a* value in the products of high AA concentration, the value fluctuated around -3.50. It seems -3 can be the threshold of the slight browning.

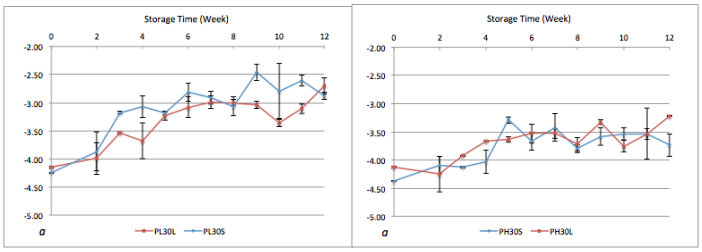

Figure 4 . *a* value changes in pineapple products (Left is low AA concentration and right is high AA concentration)

As shown in Figure 5, when the *a* value is above -3, the AA concentration is below 460 ppm. Thus, the AA concentration might be a predictor of browning. Further validation needs to be seen in the products of high AA concentration. If the pineapple also turns to be slight brown when the AA concentration is below 460 ppm or another concentration in the products of high AA concentration, AA concentration can be used as a predictor of browning.

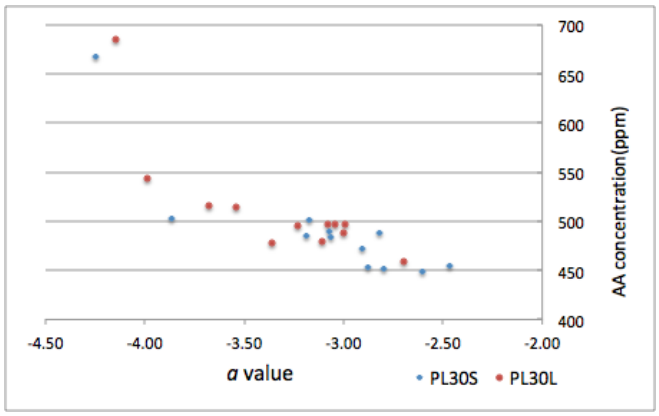

Figure 5. Scatter plot of AA concentration and *a* value

Regression analysis

Stepwise Regression:

According to the stepwise regression results, AA (between 500 ppm and 2000 ppm) has a positive effect to extend the shelf life, which goes well with the theory. And for different fruit categories, the effect of AA varies. This can be explained by the fact that different fruits have different compositions. For a certain blanching temperature, lower heat treatment temperature (between 102˚C and 106˚C) and longer heat treatment time (between 6 minutes and 16 minutes) can contribute to longer shelf life. As for blanching temperature (between 23˚C and 62˚C), higher blanching temperature leads to shorter shelf life.

Ordinal Logistic Regression:

Model built here has the best fit to the data and has good predictive ability. When heat treatment temperature is 100-110˚C, pineapple with longer heat treatment time (10-17 min) is more likely to be “ok” in term of browning test. When heat treatment time is 10-13.6 min, pineapple with higher heat treatment temperature (100-110˚C) is more likely to be “not ok” as the result of browning test, while more likely to be “ok” when heat treatment time is 13.6-17 min. There is no

literature to support the negative effect of low AA concentration (0-87.79%).

Conclusions and future research

Headspace volume and package volume, have significant influence on AA degradation by affecting the oxygen content. The degradation of AA is faster in large package and more anaerobic degradation of AA happened at bottom of large package. For future research, it would be interesting to see if there is also more anaerobic degradation in Tetra Recart 440 and 500 mL package. Additionally, there could be more anaerobic degradation in the package with high concentration of AA due to the increasing of ratio between AA and oxygen concentration, which needs further validation. These can give suggestion about how much AA is needed to reach same shelf life in different packages.

For browning reaction, the *a* value turned out to be a good indicator by using the tricolor metric system measurement. Based on the results of pineapple products stored at 30˚C, the *a* value -3 is the threshold of the slight browning while the corresponding AA concentration is 460 ppm. There are two interesting related research fields. One is the relationship between AA concentration and AA degradation during retort process. It is important when it comes to how much AA needed before retort process. The other one is the relationship between AA concentration and AA degradation pathways during storage. It is also advised to study some other indicators, such as the non-enzymatic browning index and the HMF content, to see if there is better correlation with browning reaction comparing with AA concentration.

Stepwise regression shows higher Vitamin C concentration, lower heat treatment temperature, longer heat treatment time and lower blanching temperature (within a certain range, see result) can contribute to longer shelf life. Ordinal logistic regression shows the influence of heat treatment temperature and time, AA concentration depends on the value of each factor and the interaction between factors. More variances of AA concentration, heat treatment time and temperature, diversity of fruit, quantitative browning result are expected to improve the regression model.

Protein digestion: a feasibility study

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Introduction

Breast Milk (BM) is the best source of nutrition for infants. However, when breast feeding is not sufficient or not feasible, it is important to have high quality Infant Formulas (IF) available. Traditionally, IFs are produced from cow's milk (CM) with an adapted whey to casein ratio. They are considered safe and nutritionally adequate for term infants. Nevertheless, protein digestion differs when BM or IF are consumed. Postprandial amino acid appearance into the bloodstream after protein digestion is faster in IF than in BM (Moro et al, 1999). It is hypothesized that too fast amino acid appearance will lead to amino acid oxidation rather than deposition and will have an impact on growth and development in the newborn (Sawatzki at al., 2001). For this reason, the development of IF with optimized protein quality and quantity is subject of intense investigation.

Objectives

This project aimed to develop protein prototypes, using commercially available ingredients, that would close the gap between BM and IF in protein gastrointestinal behavior and therefore nutritional efficacy. The main objectives consisted on:

(i) Set up and validate an *in vitro* static digestion model

(ii) Screen novel protein formulations

Methodology

Set up static INFOGEST digestion method was validated for reproducibility and sensitivity to pick up differences between IF and BM using standard mainstream IF and mature BM. The method was reproducible, detected differences between reference samples and was therefore used for protein formulation screening. IF and BM are composed of proteins, fats, sugars and minerals. As the project scope was to test protein formulations, IF protein formulation was created and further used as a reference for tested protein prototypes.

Novel protein formulations were evaluated for its digestion pattern. Protein formulations were prepared by mixing casein and whey ingredients to 1.3% protein as in IF to comply with the European regulation. Casein to whey ratio was adjusted as in mature BM. Six protein formulations (A,B,C,D,E,F) closer to BM in terms of intact protein composition were prepared digested and analyzed.

Conclusions & future prospects

Protein formulation F was found to be a promising prototype for its digestion pattern closer to the reference. For future research, the number of replicates should be increased to have a statistical significance. The effect of full matrix as well as the impact of processing should also be tested and considered for future upscaling.

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The influence of pH and mineral composition on stability of infant formula

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Introduction

Infant formula is a product based on cow´s milk, aiming to provide a breast-milk substitute and it needs to satisfy the nutritional requirements of infants from the first months of life until the complementary feed is introduced.

Production process of powdered infant formula consist of several steps, where at the first stage raw ingredients are dispersed together and solubilized. The mixture then goes through different steps of heat treatment, where desired (destruction of bacteria) and undesired (protein denaturation/ aggregation, mineral precipitation, etc.) changes occur (Singh, 2004).

It is the aim of process, to provide safe & quality products and as well maintain efficiency of the production line. Efficiency mainly relates to eliminating the effect of the “fouling” (e.g. deposit formation, filter blockage in heat exchangers). This is the same thing that can happen when fresh milk is heated in the pot (Figure 1, top). In the case of infant formula, processing parameters and formulation (recipe composition), can both have a severe effect in deposit formation (Figure 1, bottom).

The heat stability of the infant formulas is mainly related to the conformational changes of proteins during the heat treatment. Among proteins, whey proteins are the ones highly sensitive to heat induced changes, whereas casein proteins are shown to be

high heat stable. Unfolding of the whey proteins and further aggregation with other whey and casein proteins is a leading cause of the fouling.

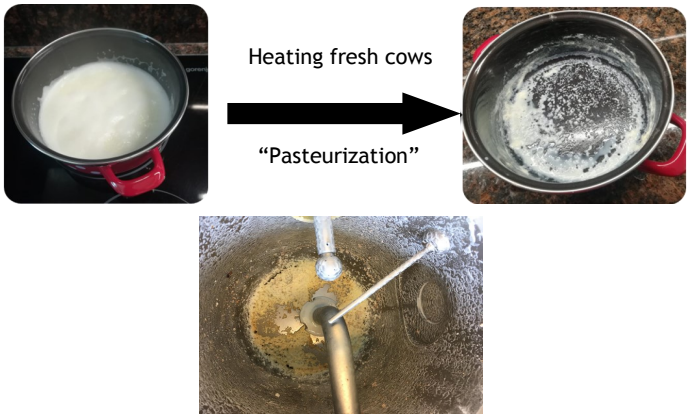

Figure 1: Top - Coagulation of milk proteins and formation of the deposit on the bottom of the pot. Bottom - Fouling in the pilot plant, deposit formation in flash cooler.

Severity of the interactions and the type of aggregates that can be formed (soluble/ insoluble), strongly depends on the pH of the recipe and the minerals in the system. The presence of minerals, especially in the "free form" as ions, can increase the non-covalent interactions, thus promoting aggregation and decreasing the heat stability (On-Nom, et. al. 2012; Prakash, et. al., 2015).

For the scope of the project, the influence of pH and addition of minerals was investigated to characterize the heat stability and define the optimum pH of the recipe.

Research objectives

1. Develop a suitable method for characterizing the heat stability in the lab scale
2. Define the optimum pH of the recipe, conducting heat stability methods and pilot plant trials
3. Observe the effect of free calcium ion at the optimum pH of the recipe

Methodology

Whey based infant formula was used for characterization of heat stability in lab and pilot plant trials. The samples did not contain any oil and the focus was on protein observation

Formulation

Recipes were reconstituted and adjusted for the pH before the heat treatment. After the screening and lab experiments with the heat stability methods, pH between 6.5 to 6.9 was used in pilot plant trials.

After pH selection, the recipe was selected for one pH and the minerals were added to increase (addition of $CaCl_2$) or decrease (addition of Tri-sodium citrate/Di-potassium hydrogen phosphate) calcium ion activity.

Processing condition

The heating conditions mainly included preheating of the milk at 85 °C and further high heat treatment at 120 °C - 150 °C.

Heat stability methods

Water/Oil bath treatment was used to (visually) measure the heat coagulation time as indicator for the heat stability. As a second, more scientific approach, method with the pressure cell was used. For that method, a protocol with the heating conditions similar to pilot plant conditions, was developed. Protocol was used for characterization of the heat stability, by measuring the viscosity profile throughout the heat treatment.

Analytical methods

The samples from the pilot plant trials were analysed for particle size distribution (PSD), microscopic observation and protein content measurements. For the protein content, method based on measuring the nitrogen and converting to proteins with the factor of 6.25, was used. Milk samples were measured

before centrifugation for total protein content. Samples were also adjusted to pH 7.0, centrifuged and measured for the insoluble aggregates. Centrifugation speed was used according to Dumpler & Wohlschläger (2017) and it was expected that mainly insoluble micelles would precipitate.

Results and discussion

Two heat stability methods showed different trend for the optimum pH. The most stable pH of 6.7 was recorded for the water/oil bath treatment, whereas pH of 6.9 was more stable in the pressure cell treatment. This was mainly concluded on the most stable viscosity profile in the pressure cell treatment for the pH 6.9.

To evaluate the accuracy of those methods and define the optimum pH, pilot plant trials were conducted.

Main observation was done on measuring the particle size distribution. The samples after the high heat treatment at 120˚C did increase in the aggregates size, but no differences was seen between different pH. As high heat treatment temperature of 150˚C was used, more differences were seen also depending on the pH of the recipe (Figure 2).

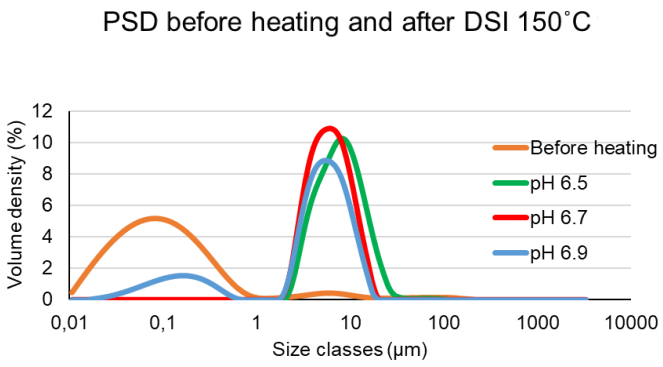

Figure 2: Particle size distribution (PSD) of the samples after high heat treatment with Direct steam injection (DSI) at 150˚C; Influence of pH

It was somehow observed , that for pH 6.9, the peak of larger aggregates (~6.3 µm) had a lower volume density than samples at pH 6.5 and 6.7. For the pH 6.9, also peak at 0.16 µm remained, believing that some unaggregated casein micelles remained in the milk. Thus, pH 6.9 was showed to be more stable one and the same trend was seen in microscopic observations. Further on, solubility measurements showed increasing the amount of insoluble aggregates as pH decreased. This was observed for the samples high heat treated at 150˚C and the pH of 6.9 resulted in the lowest amount of insoluble aggregates. Thus, the conclusion from those results, that pH 6.9 is resulting as more stable pH, was made.

Further experiments were conducted by influencing the free calcium ion activity of the recipe. Two different $CaCl_2$ concentrations, Tri-sodium citrate (TSC) and Di-potassium hydrogen phosphate (DPPHP), were used for those trials. The pH of those recipes was adjusted to 6.9.

PSD results showed increased aggregate formation, especially for high $CaCl_2$ addition. This was somehow expected, as free calcium ion activity was increased, thus promoting non-covalent interactions between proteins (Faka, et. al., 2009).

The PSD showed larger size classes when TSC or DPHP were added, comparing to the reference recipe at pH 6.9. It was whether unknown, how this impacted the actual heat stability of infant formula. The hypothesis is, that chelating salts chelated the calcium and influenced the equilibrium of calcium and phosphate between casein micelles and milk serum (de Kort, et. Al. 2011). This could result in disruption of the integrity of casein micelles, decreasing the heat stability. From

those results, it is believed that the reference recipe at pH 6.9 was again the most stable one. Keeping the pH at 6.9 and changing the calcium ion activity above or below 1.15 mmol/L with addition of different minerals, resulted in increased aggregation of the proteins. The value of 1.15 mmol/L of calcium ion activity was believed to be resulting in the most stable formula.

Conclusions

For the heat stability methods, pressure cell showed more compliable results with the pilot plant trial. It is believed, that especially temperature profile had an important role in stability of the recipe (Anema & Li, 2003), while pressure cell managed to heat and cool down the samples at a lot faster rate then water/oil bath method. Thus, pressure cell is considered as a more appropriate and accurate method for characterizing the heat stability.

PSD, microscope pictures and solubility measurements showed the more stable pH to be closer to pH 6.9. With the research, the understanding of aggregation was investigated (Figure 3). The hypothesis is, that at pH 6.8 and above, mainly k-casein dissociates from casein micelles at a faster rate, facilitating the aggregation of whey-whey and whey-k-casein proteins in the serum of the milk. Lower pH most probably results in big (insoluble) aggregates, as whey proteins are believed to directly attach to micelles surfaces (Vasbinder and de Kruif, 2003; Dissanayake, et. al., 2013).

The mechanism is proposed based on understanding that whey proteins are most probably interacting with k-casein via disulphide exchange interactions. In that way, the dissociation of k-casein can promote the formation of soluble aggregates in the serum of the milk.

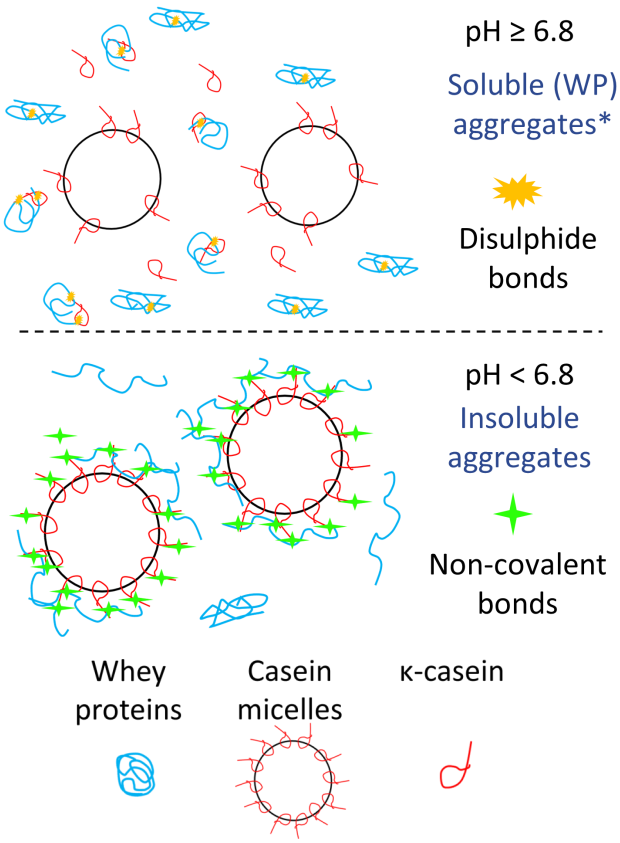

Figure 3: Proposed mechanism of aggregation depending on the pH of the recipe. pH of 6.8 and above is the point for rapid increase of k-casein dissociation, meaning that less whey proteins will aggregate with the casein micelles itself.

For the influence of minerals, it is only believed that calcium ion activity does have an impact on the stability. Besides that, addition of soluble salts (e.g. $CaCl_2$) should be avoided/minimized in the recipes as icreased non-covalent interactions will occur. Chelating salts (TSC, DPHP) addition should be further investigated for the impact on the heat stability.

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Physiochemical and sensory properties of novel sous-vide product, Thai Chicken Satay, for elderly consumers

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Introduction

Sous-vide means “under vacuum” in French and sous-vide cooking method is a technique of cooking food under vacuum packaging with long cooking time and low-temperature treatment (LT-LT) (Baldwin, 2012). Sous-vide process includes vacuum packaging food in plastic pouches, pasteurization in hot water, rapid cooling and keeping in cold storage (Creed, 1995). Cook-chill method of sous-vide creates a ready-to-eat product that offers shelf-life extension and eating quality of food (Ghazala, 1998).

In recent years, there has been projection of a rise in senior population aged 65 and over from 17 percent to 30 percent by the end of 2025 (European Commission, 2012) where nearly 40% of elderly adults nowadays found to have dietary protein intakes below the recommended dietary allowance leading to the most common condition found among elderly, Sarcopenia. Animal-based protein-rich food is particularly beneficial, contributing a high proportion and high quality of protein to the human’s diet. However, texture, convenience and likeing-ness play a main factor when it comes to elderly’s choice of food selection (Appleton, 2016).

In this study, Traditional Thai Chicken Satay dish is developed into ready-to-eat product using sous-vide technique. The aim of the study is to use the advantages of sous-vide cooking technique to allow textural improvements of meat and convenience in preparation for elderly's needs.

Objectives

- Designing of sous-vide cook/chill process for Thai Chicken Satay
- Optimization of sous-vide cooking time and temperature combinations on physiochemical and sensorial properties
- Evaluation of storage quality on physiochemical and microbiological properties

Methodology

A design of sous-vide cook-chill process includes all processing steps from raw ingredients to final product as shown in Figure 1.

Four different combinations of times (2 and 3 hours) and temperatures (60˚C and 70˚C) were chosen for the study. Experimental design was selected base on the consideration of international guidelines of sous-vide cooking pasteurization time and temperature, ensuring microbiological safety for consumption, Table 1. As well as the structure changes of muscle tissue with different conditions. Interior temperature of at slowest heating point (SHP) was monitored throughout the cooking period.

Table 1. Control temperature and guidelines for sous-vide cooking.

Process	Internal temperature	Guidelines
Cooking	70˚C for 2 minutes	UK ECFF
Chilling	≤ 3˚C within 120 minutes	UK DHSS
Chill storage	≤ 5˚C	FDA
Reheating	75˚C ≤ within 30 minutes	UK DHSS

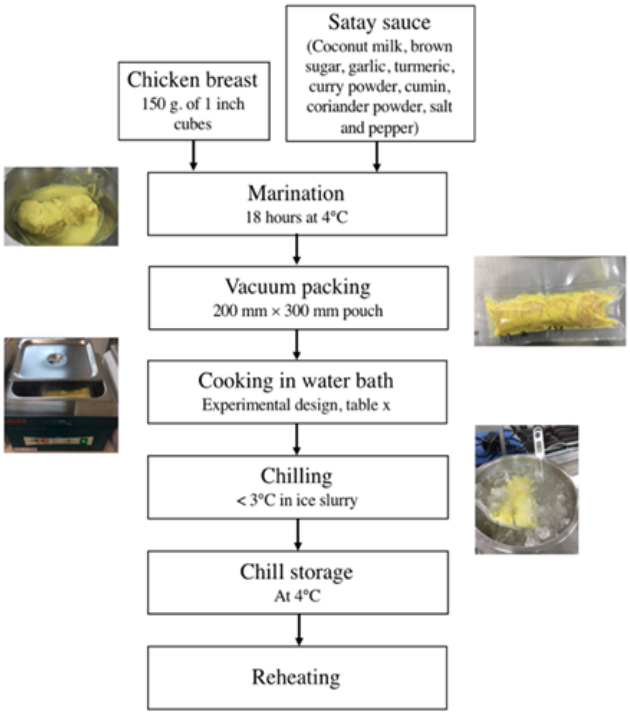

Figure 1. Schematic process of sous-vide cook/chill of Thai Chicken Satay

In order to study the physiochemical properties of the product between different cooking conditions, cooking loss (%), expressible water (%), moisture content (%), organoleptic analysis and textural measurement of Warner Bratlzer test and Texture Profile Analysis were analyzed in comparison to conventional cooking method.

Sensory evaluation was conducted and analyzed to correlates with the physiochemical properties from instrumental results.

One temperature and time condition was selected to further evaluate on its storage quality of microbiological analysis during storage period of 12 days.

Results and Discussion

The process of sous-vide cook/chill Thai Chicken Satay was successfully designed.

Sous-vide cooking at higher temperature with longer cooking time has shown higher cooking loss and lower moisture retention in

cooked chicken meat indicating a less juiciness in meat. This is due to thermal treatment cause denaturation and shrinkage of protein causing loss of water (Tornberg, 2005) (Vaudagna et al., 2002). All sous-vide cooking conditions showed a better result than conventional cooking. Results are in agreement with sensory evaluation.

- In terms of color of chicken meat, sous-vide cooking at 60˚C are less preferred by the panelists 60˚C due to the redness in meat which can be perceived as undesirable for cooked poultry products (Kieffer, Claus and Wang, 2000). Cooking at low temperature indicate a lower degradation of myoglobin (King (née Turner) and Whyte, 2006). In accordance to instrumental measurement showing high intensity of redness in sous-vide cooking at 60˚C.
- In terms of textural properties, significant difference in hardness was observed between conventional cooking and sous-vide cooking method. However, no significant difference was found among different cooking conditions of sous-vide in both instrumental measurements and sensorial evaluation.

Based on physiochemical and sensorial properties analyzed, sous-vide cooking condition of 70˚C and 2 hours was selected for further storage evaluation. Cooking with temperature lower than 70˚C show high intensity of redness of poultry confirmed by sensory evaluation. In addition, shorter cooking time showed less cooking loss and higher moisture retention. Throughout 12 days of storage shelf-life evaluation, pH, water activity remains constant with no microbiological growth observed.

Conclusion

In this work, sous-vide cook/chill process of Thai Chicken Satay dish was designed. The cooking condition was optimized from the studies of physiochemical and sensorial properties of cooked product at different temperature (60˚C and 70˚C) and time (2 and 3 hours). Results showed lower cooking loss and higher moisture retention with shorter cooking time since it allowed less water to be expelled by pressure from the shrinkage of connective tissue. In terms of color of cooked product, instrumental and sensory results are in accordance. Lower cooking temperature showed higher intensity of redness due to lesser degradation of myoglobin. Textural variables in texture profile analysis and Warner-Bratzler test, as well as sensorial results did not show any significant difference between sous-vide cooking combinations on tenderness of cooked product. Lastly, storage shelf-life of 12 days was evaluated on sous-vide cooking condition of 70˚C and 2 hours. Results showed no effect on pH and water activity as well as no microbiological growth throughout the storage time.

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Critical factors for shelf life prediction of commercial fruit product

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Improvement areas for packaging and logistics: a study of long shelf-life products in Danone Nutricia

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Profile in a nutshell:

- MSc Food Innovation and Product Design
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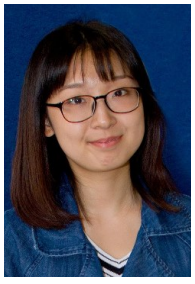

Introduction

Within the scope of the plastic bottled liquid oral nutrition adult products in Danone Nutricia, Advanced Medical Nutrition (AMN), there are over 100 types of products within this range, however, there are only 4 types of plastic bottle packaging. These products contain different chemical, physical and sensorial characteristics as well as shelf life specifications. Also, they are sold in 42 countries worldwide, which determine their various requirements towards packaging and logistics. The current 4 types of plastic bottle packaging, and similar storage and transportation conditions for all delivery routes, are not able to fulfill the diverse requirements of over 100 products.

A previous project (Kim, 2016) explored the possibilities of improving the packaging of AMN plastic bottled products by focusing on the goal of reducing the oxygen permeation and extending product shelf-life from the packaging material point of view. However, the products' specific requirements regarding sensitive components, and the conditions of storage and transport, are not studied in that project (Kim, 2016).

Research questions/objectives

- What are the requirements of the product's packaging system and logistics, regarding storage and transport in supply chain?
- What are the critical points of storage

and transport conditions throughout the product's supply chain and are there any potential opportunities for improvement ?

Methodology

To define the products' requirements a representative product with severe issue regarding packaging or logistics need to be selected. However, there is no available product selection protocol in Nutricia, the author needs to propose a practical one to facilitate the selection. Then to address the supply chain study on the selected product.

The applied methodology includes secondary and primary research. The secondary research includes bibliographic review on published scientific papers and internal reports of Danone Nutricia. It helps the author gain an overview of sensitive components of long shelf-life products and influencing factors and critical effects, storage and transport condition control during the supply chain and previous improvement projects on packaging, shelf-life and logistics. The primary research includes internal interview in person and via email to gain insights about which factors are key to build the protocol and what are the general supply chain structure and current transport and storage control conditions. Also, 2 site visits are conducted to gain knowledge about packaging system and logistics activities in manufacture and distribution center.

Results and discussion

Product mapping protocol

A mapping protocol is built to map the variations of sensitive vitamins, unsaturated fatty acid and other components that have negative effects on sensorial attributes and physical stability (Table 1).

The variation of vitamins and unsaturated fatty acid is presented quantitatively by the variation index.

Table 1 The outline of mapping protocol

Basic information	Family
	PDS Number Product Name Flavour Volume Shelf life (Month) PH
Sensitive components	Sensitive vitamins Unsaturated fatty acids Functional components Other components
Data references	

Variation Index :

$$\frac{Value\ at\ the\ end\ of\ shelf\ life - Original\ value}{Original\ value} * 100\%$$

The variations of other components, meanwhile, are introduced by scale from 0 to 5 according to their sensorial performances and physical stability during shelf life (Table 2).

Table 2 Scale of sensorial attributes and physical stability performances

Components	Sensorial attributes/Physical performances	Scale
Protein+Fat	No creaming/sedimentation	0
	Barely creaming/sedimentation	1
	Slightly creaming/sedimentation	2
	Moderate creaming/sedimentation	3
	Very creaming/sedimentation	4
	Extreme creaming/sedimentation	5
Sugar	No color/flavour change	0
	Barely color/flavour changes	1
	Slightly color/flavour changes	2
	Moderate color/flavour changes	3
	Very color/flavour changes	4
	Extreme color/flavour changes	5

Here, a value of 0 illustrates that the components are relatively stable during shelf life, while 5 means that there are extreme unacceptable deteriorations.

The mapping results quantitively distinguish products with severe nutrient degradation (VI) or instability (scale) during shelf life and upon one stand-out product the supply chain study will be addressed. Take an example by inputting the demonstration data of 3 Nutricia products (Souvenaid, Diasip, Calogen), after following the mapping protocol, the desired mapping results are shown as Table 3.

Table 3 Product mapping results

Product	Sensitive components	Influencing factors	Critical effects
Souvenaid	Vitamin B12	O2	Degradation
	Vitamin C	O2	Degradation
Diasip	Vitamin B1	O2	Degradation
	Vitamin C	O2	Degradation
	Sugar	T°C	Color/flavour changes
Calogen	Unsaturated fatty acids	T°C, O2	Flavour/ordor changes
	Protein+fat	T°C	Viscosity increase, creaming, sedimentation, crystal formation

In the end, due to the lack of key data, a representative product (Diasip strawberry 200ml) is selected according to the time frame. However, this mapping protocol still if of significance because it can be implemented in both academic research and food industry as a decision-making tool to select representative products with solid quantitative references.

Improvement areas of packaging and logistics

The studying on packaging system and logistics is based on the representative product and representative delivery routes. The issues in manufacture and central DC regarding the interaction between packaging system and logistics can be summarized in following bullet points:

1. Overhang of pallets
2. Operational efficiency, which is affected by labor-intensive repacking and picking processes and the degree of handleability of packaging system
3. Packaging material waste in many processes
4. Inefficient stacking of pallets
5. Unable to resell returned orders due to shelf life limitations

There are two routes of transportation from central DC to next logistics points, serving different countries within or outside Europe. The G4 route serves four countries including Netherlands, Belgium, Germany and France. The G38 route is designed for in total 38 countries to deliver products to countries within Europe or to the oversea countries like Brazil. In this thesis all G4 countries and 3 G38 countries including United Kingdom, Italy and Brazil are studied.

The defined improvement spaces regarding lead time and transport & storage control are summarized into following bullet points:

1) Lead time

- G4 route: long storage time at central DC
- G38 route

United Kingdom: long storage time at central DC and regional DC, long transport time from regional DC to customers

Brazil: long storage time at regional DC and long oversea transport time from central DC to Brazilian regional DC

2) Temperature control

- Storage temperature control: no control for overnight storage in Netherlands
- Transport temperature control: no control in Netherlands, Italy and United Kingdom

3) No humidity control in ocean shipment of Brazilian route, the humidity may affect the performance of the oxygen barrier of the primary packaging.

Conclusions

Requirements of packaging and logistics from product development and supply chain aspects

The requirements from the representative product (Diasip strawberry 200ml) towards packaging are:

- Storage and transport temperature within 0˚C to +25˚C
- Strong oxygen barrier
- Short lead time

Optimal temperature control aims at decreasing the degradation of sensitive vitamins and oxidation of unsaturated fatty acid as well as guarantee the sensorial attributes and physical stability. Oxygen barrier in this case requires condition control in supply chain because the barrier is sensitive to humidity, with long time exposure to humidity the barrier strength could reduce and oxygen permeation rate will increase accordingly. Regarding lead time, even under the optimal conditions, longer storage or transport time are related to more vitamin loss and deterioration of sensorial performance. In this case long-distance transport and logistics activities in distributer are time-consuming and affect the lead time to a great extent.

Improvement areas of the current packaging system and logistics

By summarizing the insights from packaging system and logistics evaluation based on the representative product, the critical improvement spaces are defined:

Table 4 Improvement areas of packaging system and logistics

	Improvement areas	Supply chain points
Packaging system	Overhang in pallets	Manufacturer
	Handleability of tertiary packaging (corrugated	Central DC
	Fill rate	Transporter
Logistics	Multiple verification	Central DC
	Packaging material waste	Central DC
	Lead time reduction	
	Lack of humidity/ temperature control	Humidity -- whole supply chain Temperature – NL/UK/ IT

Future research

Research scope expansion

In the future work the research scope could be expanded to more aseptic products of Nutricia and more distribution routes. Furthermore, with the better understanding of aseptic products and plastic bottle packaging, the research scope could be expanded to products with retort process and other types of packaging.

Shelf life testing

To verify the deviation of the key sensitive components of the representative product during shelf life, the shelf life testing which covers the whole claimed shelf life is desired. Moreover, it would be an optimal idea to test all aseptic products of AMN and to input these data to the mapping protocol to build a comprehensive database for further researches.

Supply chain verification

The information on lead time, warehousing and transportation conditions in foreign countries outside Netherlands as well as the warehouse temperature within Netherlands were acquired through semi-structured inter-

view via email. The actual situation may be different and should thus be verified in future work via on-site visits or data logger monitoring.

Moreover, the relevant experiments should be addressed to understand the influences of storage and transport on packaging system and product.

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