Developing Dog Biscuits from Industrial by-product

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From an idea to prototype

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Abstract

Have you ever wondered how we can reduce food waste and at the same time provide a more sustainable and eco-friendly environment to all of us? One of the United Nations goals is to bring by 2030 more responsible consumption and production to the environment. Industries are paying annually for solid waste disposal up to 16,000€ and at the same time, the most preferred way to dispose it is through landfill and composting. The purpose of this project is to sustainably upcycle the industrial by-product by incorporating it as a complimentary snack for canine consumption. The main goal is to become familiar with the left-over material as an ingredient in order to incorporate it in a recipe. Possible recipes were created in order to incorporate the by-product and having as a guide the new food product development process. The baked biscuits were studied for colour and texture. Audio-visual material was given from the dog owners in order to study the reactions of the dogs but also the perspective of the dog owners. The results showed that some of the formulations were in close range from the commercial dog treats. There was positive environmental feedback from the dog owners' perspective regarding the sustainable way of utilising the industrial by-product. Moreover, further improvement needs to be conducted to gain more engagement from the perspective of the dogs. The outcome of this project was significant because through this action the circularity of the economy has a way to be improved. Also, the industrial by-product is upcycled into a pet snack and it enhances the overall improvement of food waste.

Keywords: circular economy, waste recovery, upcycling, sustainability, product development

Executive Summary

Introduction

The most common and least preferred way to dispose of the solid waste from craft breweries is through landfill, composting and lastly through industrial uses (Environmental Protection Agency, 2019). In 2019 craft breweries are paying up to 16000€ to dispose their solid waste and at the same time Sweden has been described as a "Dog paradise" having more than 780,000 registered dogs in 2012; according to a study, the dog owners treat their pets as a family member (National Veterinary Institute SVA 2018, Stier 2010 and passport 2018).

Research objectives

Solely purpose, to up-cycle the by-product from craft breweries. In 2018 forecast there will be an increase of 6.6% in sales for dog food (passport, 2018).

The objectives of the thesis are to:

1. Utilise as much wet spent grain as possible to formulate a recipe for canine consumption (dog biscuit)
2. Explore the formulations of dog biscuit from wet spent grain and compare them with the commercial dog treats in physical and microbiological level.

Material and Methods

The material that was used, wet spent grain (brewer's by-product), egg, oil, different kind of flours. Following the new product development process by Earle 2017, the figure I illustrates the overall designing procedure of making a dog biscuit.

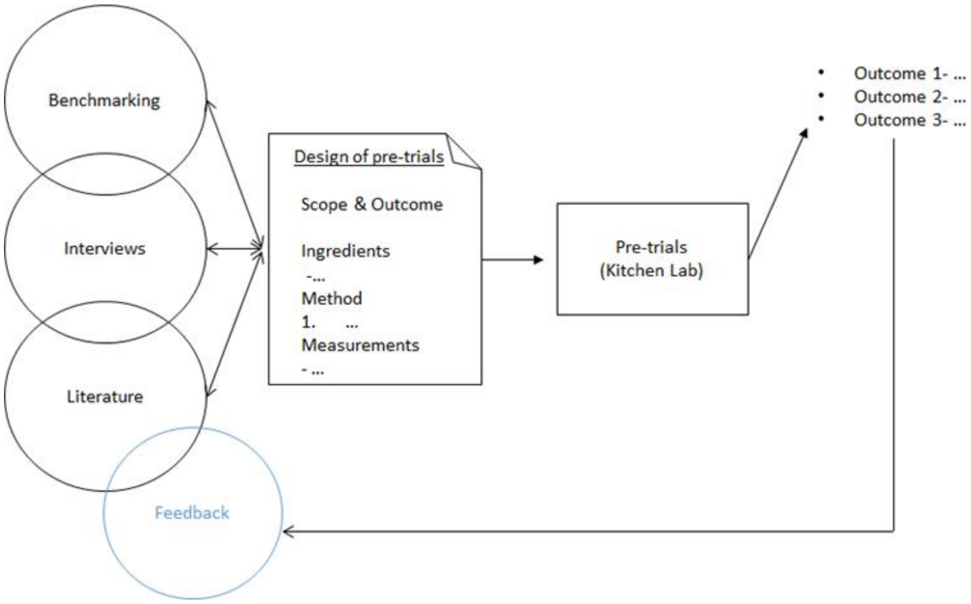

Figure I: Design process of dog biscuit

The baking process of biscuit making was conducted and measurements of water activity, moisture content, color and texture were taken for quality control. Through primary consumer approach, the product was viewed and feedback from dog owners was recorded.

Findings

Four trials were conducted to get to know the behavior of wet spent grain and get an initial feeling. To begin with, analogies of different portions of wet spent grain were viewed and a working formulation occurred when utilizing 50% of wet spent grain with rice flour. Continuing, different ingredients were studied and incorporated in the recipe such as egg, oil for creation a moldable and structural dough. Later on, experimenting with different types of flours and various formulations on texture and color was studied and the findings were compared with 3 commercial dog treats. Through recipe repetition, the unexpected occurred. The findings of color and texture were not similar among the trials.

Discussion

The levels of wet spent grain that was incorporated in a working dog biscuit recipe reach 54% the percentage. Compared to Petrović study, the creation of human biscuit from wet spent grain reaches the incorporation of 50% (Petrović, 2017). Through the trials in the kitchen, the initial feeling of how the wet spent grain behaves with other ingredients (egg, flour, oil) had a positive attitude towards creating some working formulations. Also, the comparison with commercial dog treats regarding texture and color has promising results. From quality assurance perspective, the levels of water activity and moisture content were within the limits of dry pet food legislation (European Pet Food Industry Federation (FEDIAF), 2018 and 82/475/EEC). Initial consumer approach was promising even though challenging. Dog owners showed awareness and positive attitude towards sustainable dog biscuits.

Conclusions

The maximum content of wet spent grain that can be incorporated in a recipe was identified. Consumer gave initial feedback that needs to be taken into consideration. Through the new development process, the outcome of reaching acceptable product prototypes concurred. However, due to time limitation the design process of creating and launching a final product prototype could have been possible.

Further research

Possible next steps, creation of a business strategy for supporting the product. Continuation of consumer investigation for identifying the trigger ingredients. In-depth research of product development process.

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1 Introduction

In this chapter you will view some of the biggest environmental issues and how this thesis project is going to try to tackle them.

1.1 Background

Circular economy is a widespread tool which presents solutions to some of the world's urgent cross-cutting sustainable development challenges. The passage from linear to circular economy requires a collective effort from all sectors and stakeholders. This way the design and implementation of products' reuse and recycling lie in companies' effort (Unger, 2018).

By 2030, the world's sustainable agenda has to bring prosperity to people and to the planet and the challenges that craft brewers facing can be linked with the N°12 sustainable goal for "responsible consumption and production". Every year, there is land degradation and approximately ⅓ of all food is wasted. Through upcycling, which is the conversion of by-product (food waste) into materials or products for better quality or environmental value, there is a contribution to the sustainable goal N° 12 (United Nations Sustainable Goals (UNSG), 2019). When sustainability is desired the question of how the food waste is managed comes down to the environmental protection agency and us the consumers. According to Environmental Protection Agency of United States (EPA) there is a prioritization in the actions on how food disposal is been structured (see figure 1). As it is described, the least preferred means for food disposal hierarchy is landfill but this is what currently is happening in the craft breweries, therefore a more preferable solution needs to be implemented for tackling the brewer's solid waste (Environmental Protection Agency of United States (EPA), 2019).

Figure 1: Food recovery hierarchy (EPA, 2019)

1.2 Research Problem

Craft breweries in Sweden are steadily increasing (The brewers of Europe, 2018). Annually, they are paying 1400$ - 18000$ (1,254.41 € to 16,128€) for their solid waste to be disposed of (Stier, 2010). Brewers are being conscious of sustainable practices when producing beer. The craft brewery faces various challenges such as, energy, water, agriculture, packaging and distribution but through the framework for strategic sustainable development (FSSD) practices those challenges could lead on a positive impact by boosting local connections and economy, social interactions and cultural identity (Grunde, 2014).

More specifically, one of the major challenges that craft breweries face is food waste when producing their own beer. This by-product is called wet spent grain (WSG). It has very short self-life due to high moisture content (Lynch, 2016). Due to frequent shipping all year round the transportation of WSG is costly (Kocher, 2018). Currently, the best practices to reduce, reuse and recycle the wet spent grain are mainly in landfill, as animal feedstock, production of biogas for generation electricity or heat and less known practices are distribution in local bakeries, composting by local farmers as fertilizer for growing mushrooms, as a scrub soap and even as a feed for fisheries (Brewer’s Association 2018, Heuvzé, 2017 and Galanakis 2018)

Therefore, the problem of this study is to explore the possibility of successfully utilize the wet spent grain in a sustainable way through upcycling in order to help positively the environment. Even though, environmental responsibility is widely spread in Scandinavia. Sweden has been described as a “Dog paradise” having more than 780,000 registered dogs in 2012 (National Veterinary Institute SVA, 2018 and passport 2018). The statistical representation of dog distribution in the European Union (EU) can be seen in Appendix F (European Pet Food Industry Federation (FEDIAF), 2017). A recent study, came to light and revealed that half of all dog owners treat their pets as family members resulting that Swedes invest money into dogs food (Passport, 2018).

1.3 Purpose and Objectives

The purpose of the thesis is to successfully upcycle the by-product of the craft brewery (wet spent grain). Sales of dog food in Sweden have a significant increase by 4% within a year, from 2017 to 2018, and the forecast (see Figure 2) shows a steady increase by 6.6% till 2023. Also, the trend of premium products and/or ingredients tent to rise (Passport, 2018).

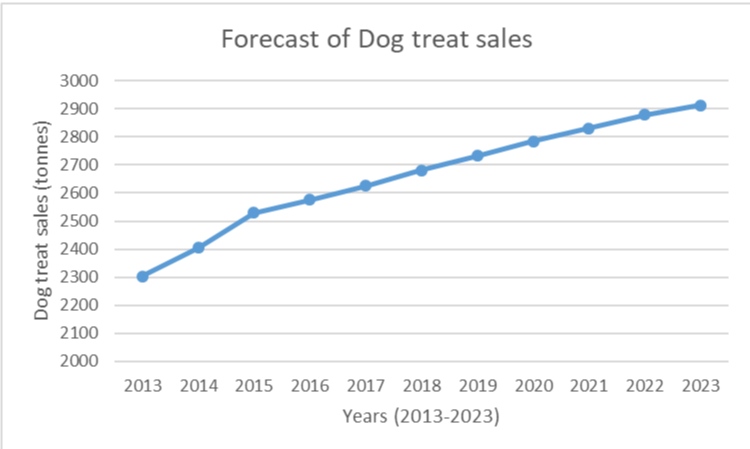


Figure 2: Forecast of Dog treat sales until 2023 (adapted from Passport, 2018)

Therefore, the combination of reducing food waste while upcycling the brewers' by-product while there is a steady increase of pet treats in the Swedish market seems good way to begin with. This upcycling initial will be explored by developing a functional baked product for canine consumption as complimentary food.

The objectives of the thesis are to:

1. Utilise as much wet spent grain as possible to formulate recipe(s) for canine consumption (dog biscuit)

2. Explore the formulations of dog biscuit from wet spent grain and compare them with the commercial dog treats in physical level.

1.4 Focus and Demarcation

The focus of this thesis is the creation of a biscuit for dogs that has characteristics from existing commercial dog treats. Focusing more in the sustainable ingredients. The focusing measurements are described in chapter of material and methods.

The business strategy was not considered in this thesis project since it is a different stage and will be taken into consideration later. Therefore, business model, costs of the process and the ingredients are not being considered. The nutritional value and the healthy (if any) aspects of the developing product are not examined. Also the interviews with dog owners are limited in the area of Skåne region, Sweden.

1.5 Thesis outline

This section describes the layout of this master thesis work. The project starts by introducing the background, the research problem, the purpose and objective followed in chapter 2 where is developed a coherent literature review of the project. Chapter 3 has the materials and methods that were used for the completion of this project. Chapter 4 explores the insights of craft breweries. Chapters 5 and 6 are present the most fascinating findings along with the discussions. Closing, chapter 7 presents the conclusions and further recommendations for this project.

2 Frame of reference

An outline of the description of product development processes, canine diet, beer brewing process and baking science.

2.1 Product development processes

There are many ways to approach the creation and development of a new product. According to Rudder 2001 there are a number of people who took the initial steps. Those were Booz, Allen and Hamilton in 1965 where they took into consideration the business approach forming a product team and monitoring the targets. They had understood that by observing and recording the consumer preferences they could develop a successful product. Later on, Kotler and Armstrong in 1991 pointed the urgent need to find possible failures before they become economical unbearable mistakes. Urban and Hauser in 1993 and MacFire in 1994 offer a new product development (NPD) plan which was proactive and company oriented. However, from 1965 till 1994 all the NPD processes were not focused on food resulted alterations in order to fit the sensory properties of food (Rudder, 2001).

2.1.1 **Stage-Gate model**

An industrial applicable model for developing and launching successful products or services is the Stage-Gate model. It is a valuable business oriented process that through benchmarking brings into the companies table the approach of creating successful products or services. Five attributes exists to ensure product or service success. First, customer driven is focusing in high rates in success and profitability. Second, upfront activities having early design to eliminate expensive last-minute changes. Third, Go/Kill decision points are in projects you identify when you don't have enough resources and you "kill" the stage with this gate and vice-versa. Fourth, existence of truly cross-functional teams making sure there is diversity and capable project leaders are in place. Fifth, top management involvement include committed and visionary member (Edgett, 2019).

The typical Stage-Gate process follows in the figure 3. For a successful product that is launched into the market the product innovation begins with ideas. The NPD process is usually broken down into smaller stages where a plan of action is carried and gates where Go/Kill actions are taken.

The Stage-gate model explained in detail below (Figure 3). Initially the discovery phase is to identify business opportunities and the generation of new ideas.

1. Scope stage refers to the inexpensive broad preliminary research of the project or the desk research.
2. Design stage is the detailed investigation with primary research from customer, markets and technician lead to a planned business plan for development.
3. Develop stage in detailed is the product development and the necessary process for production.
4. Scale Up stage is the trials in the lab, plant and market place to validate the proposed new product
5. Launch is the final stage which the commercialization, full scale operation or production, marketing and sales taking place.

The Gates provide the quality-control checkpoints by inspection of the execution, evaluation and approval of the project plan and its assets. For instance, Gate 1 is easy to pass but Gate 3 it requires a tougher decision (Edgett, 2019).

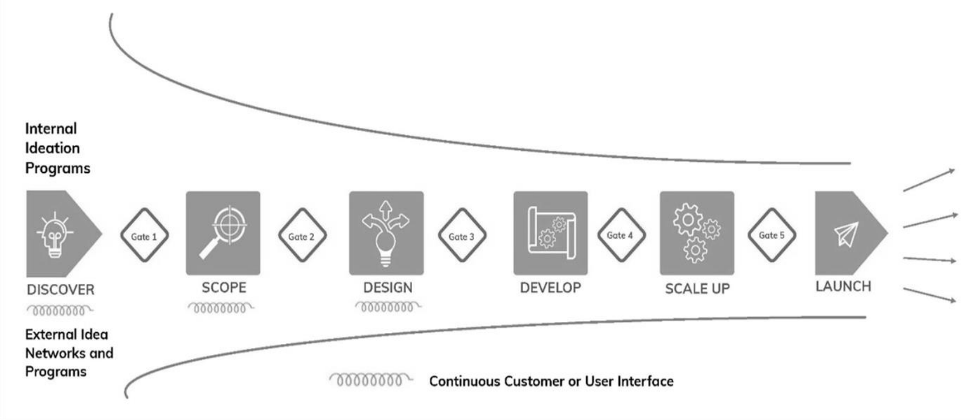


Figure 3: Stage-Gate process (Edgett, 2019)

2.1.2 Food product development process

There are different processes Ainsworth 2001, Graf and Saguy 1992 and Fuller 1994 to develop a new food product. More in detail you can find them in Appendix D. But the development process that has gained attention is by Earle and has 4 stages (Figure 4). Earle (2017), describes the food product development process as critical because it is based on critical decisions, analysis and outcomes. A general overview of the product development process is by knowing the consumer needs and having the scientific and technological developments to support the product development.

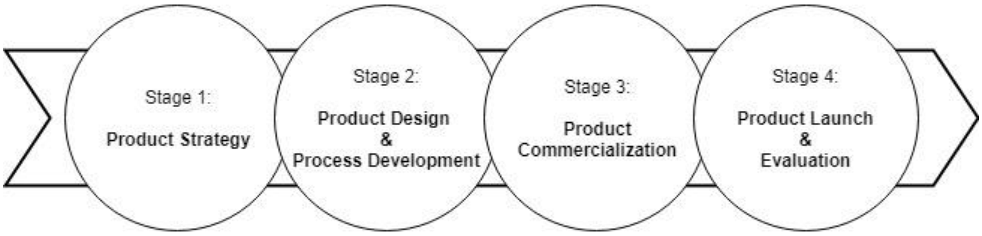


Figure 4: Food Product Development Process by Earle (adapted, Earle 2017)

The critical product development process has 4 main stages that are subdivided into 7-9 stages that are called stage gates or critical points. Critical points are vital for the process. The generated knowledge is described as outcomes and the building of this knowledge as activities. In this section is analysed the Stage 1, 2 and the sub-stages. The analysis of the stages 3 and 4 in product commercialization, product launch and evaluation are not going to be thorough developed (Earle, 2017).

Stage 1 (see figure 5) in product strategy development has a blast of creativity in ideas that are developed. The sub-stages to form a) product concepts and b) designing the specifications are interrelated and integrated with each other. The industrial (total quality management (TQM) and hazard analysis control point (HACCP)) and consumer-oriented requirements for safe and nutritious food are in demand. In the sub-stages the actors that play important role are consumers, marketers, production employees, engineers and product developers.

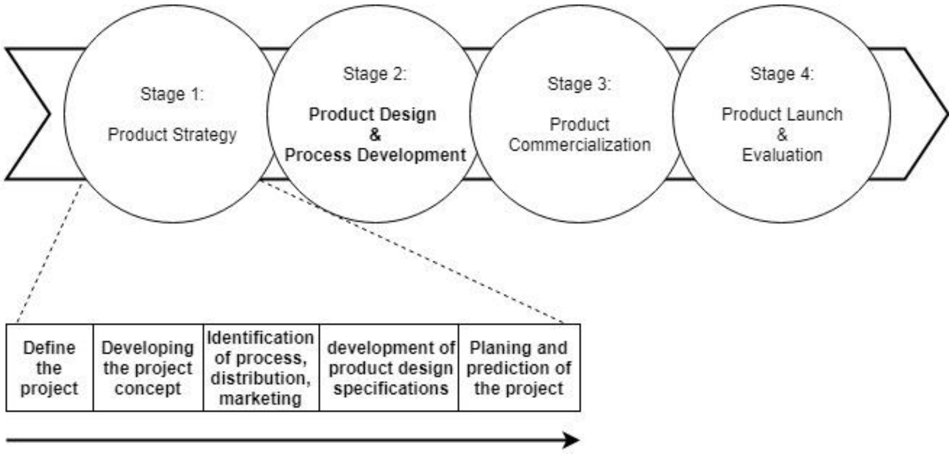


Figure 5: Stage 1 – Product strategy (adapted Earle, 2017)

Stage 2, can be described as an intense process that involves integration, creativity, systematic planning and monitoring. Meaning that the process and the product are parallel developed (see Figure 6).

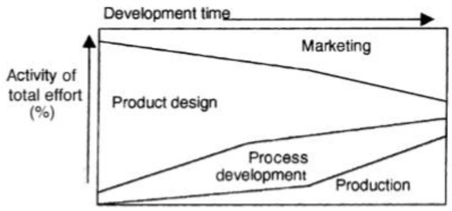


Figure 6: Integration in Product Design (Earle 2017)

Before starting with Stage 2 (see Figure 7) is needed to have roughly described the product design specification from stage 1. This stage takes a great deal of time and discipline. Planning is a necessary tool which helps in coordinating of people and activities. It starts with knowing and defining products' design specification. Starting with a general description of products' specifications helps in further descriptions. Marketing, technical and economic aspects need to be taken into consideration in food product design (Earle, 2000).

A detailed explanation of the sub-stages in the stage of design process follows, were in square shape the activities are described and in the oval shape the outcomes (Figure 7).

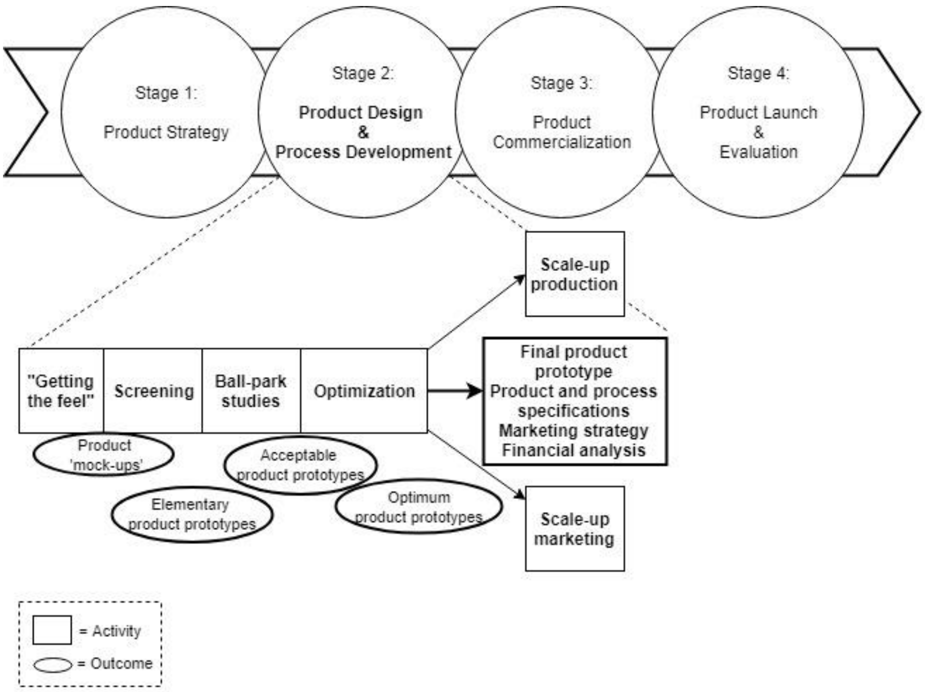


Figure 7: Stage 2 – Product Design and Process Development, activities and outcomes (adapted Earle 2017)

- "Getting the feel": The development of the product's concept and the products' design specifications are continued. An early prototype is born and the technical settings are identified. It is worth mentioning the 'ad-hoc' experimentations where you try and see what the outcome is. There is a possibility of consumer involvement depending on designer. Also basic costing is identified.
- Screening: Narrowing down the wide range of raw material and focusing in less processing variables. This speeds up the design. The variables are narrowed through previous knowledge of the designer or company information or bench-marking or interviews. There are some food designers that are using sensory trials to check the acceptability or the product's profile.
- Ball-park studies: This stage in about setting the limits of the raw material and the processing variables which are acceptable product qualities by consumers. In this stage technical and consumer testing is required for these product prototypes. The consumers (dog owner's and dogs) are tested for acceptability and the technical tests include the chemical, microbiological, physical and sometimes sensory properties of the product are set.
- Optimization: Optimize and balance the overall product quality.
- Scale-up in production: Is the last stage and usually happens to make sure the required quality and quantity is able to be delivered by determine the optimum production process in pilot or small-scale plant.
- Scale-up in marketing: Is usually happens parallel or close in time-frame with the production scale-up. It is a large scale -up consumer test to define the market as been predicted and verify that the target consumers will purchase the product (Earle, 2000).

2.2 Canine Diet

Over the years domestic dogs (*Canis Lupus Familiaris*) have evolve their diet due to human domestication from carnivores to adaptable carnivores and lastly to omnivores (Bekoff 2006, McDonald 2011, Wall 2019). Nowadays, dogs have the ability to digest starch-rich diet (Axelsson, 2013).

A balanced and healthy canine nutrition is based in all six nutrient categories; water, fat, protein, carbohydrates, vitamins and minerals (American society for the prevention of cruelty to animals (ASPCA), 2019). The amount of each ingredient that the dog need to have be according to various factors such as age, breed and activity levels (ASPCA 2019 & McDonald, 2011). According to Case 2011, a proposed diet intake of an adult dog to maintain its weight is 20- 25% Protein, 35-45% Carbs and 35-40% of Fat (see Figure. 8) (Case, 2011).

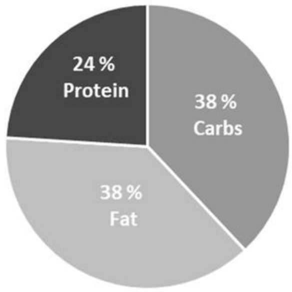


Figure 8: Adult canine nutritional maintenance (adapted Case, 2011)

Pet owners purchase treats as a way of showing love and affection to their pets. By offering them snacks, generation of a positive feeling of nurturing and the expression of affection is expressed. Also they treat them to obtain a desired behaviour that is been acquired through training. Food variation to the pet is chief importance. Treats are often purchased on impulse or because of novelty, owners are more likely to try a new flavour or type of treat than they are to completely switch dog treat (Case, 2011). The treats do not have to be nutritional complete, however, in the market nutritious treats exist but are more costly (Guy, 2016).

2.2.1 **Energy Balance**

Protein, carbohydrates and fat provide energy to the dog. Energy balanced is accomplished when calories consumed is equal to the calories burned (example through exercise) (Case, 2011). Energy or caloric value of pet food can be measured using calorimetry. Different type of food energies exists as follows, gross energy (GE), digestible energy (DE), metabolized energy (ME). The energy requirements for dogs are expressed in kcal of ME and during growth, reproduction, physical activity and exposure in cold environmental conditions the need of kcal is higher. The dog's energy requirements are expressed in GE values. Therefore, the GE values for mix carbohydrates are 4.15kcal/g for fat is 9.40kcal/g and for protein is 5.65kcal/g (Case, 2011).

2.2.2 **Digestibility to pet food**

Dogs have low digestibility to pet food due to their anatomy. The digestion track of the dog is simpler with emphasis in digestion that happens in the stomach first. Then in small intestine and last in the large intestine (figure 9).

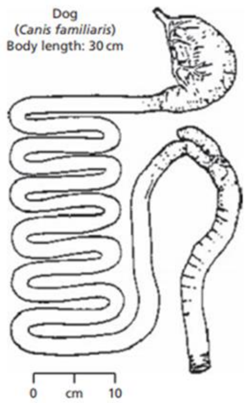


Figure 9: Schematic representation of dogs’ digestive track (Case, 2011)

Crucial point is that the saliva of dogs has no a-amylase activity that is because their natural diet is low in starch. The gastric lipase and pepsin exist in dogs’ stomach and according to the type of protein and volume of meal they consume the release of gastric lipases and pepsin are regulated. In dogs, gastric juice has antibacterial activity and in the large intestine the digestion of ingredients occur in only 8% (McDonald, 2011).

During digestion dogs cannot direct break down and absorb the same dietary fibres. It appears that the best fibre sources for companion animals are those that are moderately fermentable and provide adequate levels of short-chain-fatty-acids (SCFAs). Certain fermentable fibres act as prebiotics when included in the diet (Case, 2011).

2.3 Beer Brewing and Grains

A simple scientific description of how the beer is made goes back to the 6th BC. Begin by steeping (soaking) the source of grain in water. Then fermentation occurs and the produced product, beer, is sweet liquid with yeast. There are 4 main ingredients that are used the major one are water, grains and malts for instance barley, brewer’s yeast and hops for flavour. Different type of grains (wheat, oat, rice) are used to minimize cost or to add a second feature in the final product. In the detailed flowchart of beer process (Galanakis, 2018) there is a display of each stages’ by-products (figure 10) (Galanakis, 2018).

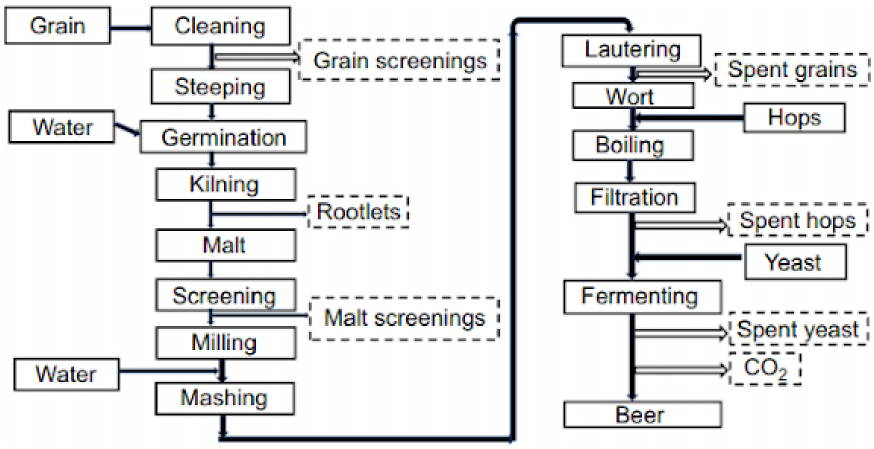


Figure 10: Brewing flowchart with by-products (Galanakis, 2018)

The spent grain is obtained after the lautering phase and before the wort is been proceed to the next phase which is fermentation. Mash is the terminology for crashed germinated cereal grains (see Figure 10). The germinated grains are made by soaking them in water allowing them to sprout. Then the process is stopped by drying them in hot air. The mashing happens in specialized factories that are devoted in producing malts. Malting is when with the help of enzymes the seeds starts to grow (germinate) and with the help of the enzymes the sugars from the starch are break down. Slowly the seeds will continue to grow till they consume all the starches that they need for the brewing process. Then according to the kilning step with various temperatures there are different varieties of produced malts. The roots that have been developed are been removed mechanically. Lautering is a term used in the breweries to describe the process in which the mash of cereal (barley etc.) with water is separated into the clear liquid wort and the residual grain (Mosher, 2017).

The brewery process is complex and there are a lot more by-products that are been thrown away. One of them is the brewer's yeast (*saccharomyces cerevisiae*) which is it used as a natural method of flea control in dogs. This happens if the dog owner concerns about flea medication so they apply the brewer's yeast instead. However, it is not verified that it actually works (Messonnier, 2012).

When the by-product of the cereals spent grain are taken, the hops (scientific name: *Humulus lupulus*, family of *Cannabidaceae*) are entering the brewery cycle. In this point it is worth mentioning that the hops are not coming into the spent grain waste. This clarification needed to be made due to the dogs are toxic to the hops (Galanakis, 2018). If they consume mistakenly hops then they develop a series of symptoms such as panting, high body temperature, seizures, death. But of course the food poisoning can be treated with a visit to a veterinarian (American Society for the Prevention of Cruelty to Animals (ASPCA), 2019)

2.3.1 **Grains**

According to 2007, Swedish agricultural datasheet the total production of cereal reached more than 5 tones meaning that more than 40% of the arable land is with cereals. Wheat and barley are most grown in south and central Sweden. Oilseed production mainly in rapeseed and colza is also located in southern areas. Potatoes are grown in all Sweden meanwhile sugar beets grow only in southern parts (Jordbruks verket, 2009).

Table 1 shows the statistics on crop production globally and in Europe obtained from the USDA, 2019. In Europe the ranking of the produced crops is wheat, corn, barley, oats, rice (United States Department of Agricultural (USDA), 2019). The European wheat production is 6 % higher in 2017 compared to 2016. The rough drought conditions in southern Europe did not interfere from the cereal to be harvested (Eurostat, 2018).

	Projection of production in April 2019 in million metric tons (mmt.)	
Crops	World	Europe
Wheat	732.9	137.0
Rice	501.4	1.9
Corn	1,107	63
Barley	140.7	56.2
Oats	22.1	8
Potatoes	-	62

Table 1: Grain growth in Europe and globally (adapted Eurostat, 2018 and USDA, 2019)

2.3.2 **Malting**

The germination starts when the grains are been soaked in water for 2 days (30-50 hours) till they obtain 45 % of humidity (Kopsachilis, 2005). This step is called steeping (Galanakis, 2018) When the cereal have the required humidity start to germinate at 15 degrees temperature. The chemical reactions that take place are the hydrolysis of starch. Hydrolysed starch is altered in smaller particles of dextrin and even small particles of glucose. Through this we obtain a-amylase. The optimum pH for a-amylase is 5.5 where germination happens at 70 degrees Celsius (Kopsachilis, 2005). Through the process of malting we have the total conversion of starch to simple sugars. In many craft breweries the germination phase is emitted due to high cost of production and in depth technological and life learning expertise. Therefore, many craft breweries obtain the malts from the malters.

2.3.3 **Mashing**

The majority of breweries starting their beer making business at this point, mashing. In the malting stage the grains have already been germinated, in the mashing stage where the soaking up of water from the smashed malted grains happen. The release of all the starch in the wort and to make easier for the yeast to "work" this called saccharification process (Mosher, 2017). There is no remaining starch in the cereal that is used in the brewing process. The table 2 complement the above statement (Lynch et.al. 2016).

Component	Kanauchi et al. 2001 *(86)*	Santos et al. 2003 *(7)*	Carvalheiro et al. 2004 *(87)*	Silva et al. 2004 *(88)*	Mussatto and Roberto 2006 *(8)*	Celus et al. 2006 *(16)*	Xiros et al. 2008 *(27)*	Jay et al. 2008 *(89)*	Robertson et al. 2010 *(19)*	Waters et al. 2012 *(9)*	Meneses et al. 2013 *(18)*
Hemicellulose (arabinoxylan)	21.8	n.d.	29.6	41.9	28.4	22.5	40	n.d.	22–29	22.2	19.2
Cellulose	25.4	n.d.	21.9	25.3	16.8	0.3	12	31–33	n.d.	26.0	21.7
Starch	n.d.	n.d.	n.d.		n.d.	1	2.7	10–12	2–8		
Protein	24	31	24.6	n.d.	15.2	26.7	14.2	15–17	20–24	22.1	24.7
Lignin	11.9	16	21.7	16.9	27.8	n.d.	11.5	20–22	13–17	n.d.	19.4
Lipids	10.6	3.0–6.0	n.d.		n.d.	n.d.	13	6–8	n.d.		
Ash	2.4	4.0	1.2	4.6	4.6	3.3	3.3	n.d.	n.d.	1.1	4.2
Phenolics	n.d.	1.7–2.0	n.d.		n.d.	n.d.	2.0	1.0–1.5	0.7–0.9		

All values expressed in g per 100 g dry material (% w/w); n.d., not determined.

Table 2: Chemical composition of Brewers Spent Grain (Lynch et.al. 2016)

The usual temperatures that mashing is happening are in a range of 65-75℃ for about 60 min (Mosher, 2017). That is stated to verify that the obtained wet spent grain is in perfect hygienic condition.

2.3.4 **Spent Grain**

According to Heuzé 2017 spent grain (SG) has a variety of names. For instance, you can find it as *Brewers grains (BG), brewer's grain, wet brewer's grains, dried brewer's grains, brewer's spent grain, wet spent grain* in English, as *Βυνοϋπολείμματα, υπολείμματα σιτηρων/ κόκκων ζυθοποιίας* in Greek and in many other languages.

The spent grain is obtained when the mashing is over (Mosher, 2017) approximately, there is 85% of by-product obtain after brewing (Galanakis, 2018). Spent grain is a very captivate ingredient because depending on the type of beer, you have different cereal species that breweries use. Some scientific names are *Hordeum vulgare L.* (is a type of barley); *Oryza sativa L.* (is a type of brown rice); *Sorghum bicolor* (L.) *Moench* (*Sorghum* is the fifth major staple cereal after wheat, rice, maize and barley); *Triticum spp.* (is a type of wheat that is one of the most important staple food crops for humans mainly derivate for wheat brewer's grain); *Zea mays L.* (corn, maize grain). The spent grain composition depends on the raw materials of the brewing process: barley variety, harvest year, malting and mashing conditions, as well as the type and quality of other cereals added to the brewing process. Brewers' spent grain is typically recovered as a wet material containing less than 30 per cent (w/w) of dry matter and 70-80% of moisture content (Galanakis, 2018). The main components of brewers spent grain are cellulose, hemicellulose, i.e. arabinoxylan, lignin, protein, lipids, low molecular weight phenolic compounds and not detectable starch component (table 2 and figure 11) (Lynch et al., 2016).

Brewers' spent grain (BSG) is considered as a plant biomass that contains approximately 20% protein and 70% fibre (Mussatto et al., 2006). BSG is mainly composed of the husk pericarp and seed coat, which is rich source of lignin, cellulose, hemicellulose it reaches up to 50%w/w of brewers spent grain lipids and protein (Ikram, 2017). The shelf-life of brewers spent grain ranges from 7-10days in warm climates (Mussatto et al., 2006). Due to high moisture wet spent grain content that leads to short shelf life as well as the existence of bulk production; there is a need for often transportation of WSG for disposing it as a food waste. The transportation of WSG is costly because it requires a lot of trips for emptying it from the food industry (craft breweries) to the food waste facility. Therefore, the transport of WSG disposal is limited to 150-350 km around the craft brewery (Crawshaw, 2004). Last but not least, brewers spent grain contains phenolic compounds (ferulic, pcoumaric, caffeic acids) which have many bio functions (at least in humans) (Ikram, 2017).

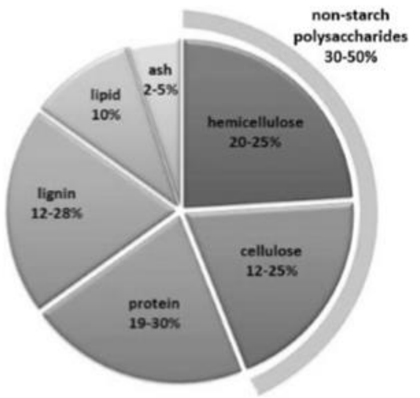


Figure 11: Typical barley BSG composition (Ikram, 2017)

From Ikram, 2017 the brewers' spent grain is a rich source of fibre, protein and phenolic compounds. It is shown to be very good ingredient for the human consumption. For instance, in ready to eat snacks, cookies, breadsticks and bread generally is added to increase the fibre and protein content (Cepeda-Vazquez 2018, Petrović 2017, Ktenioudaki 2012)

Brewers are increasingly concerned on how to deal with their solid waste. The most known usages of spent grain is feed for animals mostly ruminants which can digest cellulose-rich food. Few categorise the wet spent grain is tested to cattle, goats, pigs, poultry, rabbits and fish. Other ways were, as a scraping item in hand and face soap (Mosher, 2017 and Ikram, 2017).

2.4 Science of Baking Biscuit

Have you ever wondered where the origin of the word biscuit came from? According to Misra 2014, biscuit derives from the Latin word *panis biscotis* and means twice cooked bread. The original process is baking the biscuits in a hot oven and then drying them out in a cool oven. In figure 13 the process flow of making a biscuit is shown. There are different meanings for biscuits such as a) small round bread raised with baking powder or soda b) small flat sweet cakes in a large variety. In general, biscuits are known to have cereal based products that are baked and the moisture content is below 5%. However, the major components are fat and sugar. Understanding how ingredients interact with each other when it comes to structure a few researchers have point out that the raw materials especially the flour plays a crucial role to the quality of the product (Misra 2014).

2.4.1 **Ingredients**

The most common biscuit ingredients, for human consumption, that used are wheat flour, eggs, sugar, fat and other minor ingredients. The common ingredients for dogs can be seen in the Appendix G.

2.4.1.1 Water

Have you ever wonder if water is just a simple ingredient or a complex one? Perhaps is the most essential baking ingredient. The wet spent grain contains approximately 80% of water content the rest of the ingredients have some water although are not defined. The extra water that enters is to help mixing the rest of the ingredients in order to create a whole unified dough with the desired texture, flavour, taste, aroma and mouthfeel. It is inevitable for the ingredients not to interact with each other. Water is a trigger to the ingredients, when is added the protein chains mingle with each other and form sticky globules. Wheat flours contain water-soluble pentosans, a polysaccharide composed of five carbon sugars called pentoses. At high temperatures the starch gelatinize. The above interactions are linked to the resulted phenomena with water (Chieh, 2014).

2.4.1.2 Lipids

Lipids belong in the group of macronutrients. The main difference between fat and lipids is that the latter belongs in a broader group of biomolecules and fat is a type of lipid (Lakna, 2017). The lipids in foods are butter, margarine, cocoa butter, vegetable shortenings, a large variety of lard (Zhou, 2014).

The addition of fat to food products is to offer the sensory features such as creaminess, mouthfeel, spreadability, melting profile, cohesiveness and structure. Shortenings help for better handling of dough. Water and fat globules compete with other on which one will occupy more space during mixing (Maragoni, 2014).

2.4.1.3 Eggs

"Which came first: the chicken or the egg?" Let us begin by saying that the chicken's product, eggs are an incredible food derived. Through its rich nutrients it can be incorporated in a variety of food products. A chemical composition of a medium whole egg (55gr) is 75.2% of moisture, 12.6%protein, fat 10.5% and ash 1.0%. Yolk and white parts of the whole egg provides with different special functionality for instance the egg white when is added in the food systems creates foam. The function that the egg provide when added is improvement of colour and flavour. Also, it acts as emulsifier, whipping, foaming, coagulating or gelate agent in the products. In the biscuits the focus lies in the coagulation or gelation with the used ingredients. Applying heat more than 70℃ in liquid egg, the protein denaturation and coagulation occurs. Also, external parameters for example mixing, heating affect the food structure of the final product. Overall, incorporating eggs in the baked products boosts the product with nutritional value, desired functional characteristics and increase self-life (Kiosseoglou, 2014).

2.4.1.4 Flours

Flour is a powder that is made from grinding raw grains (example cereal), different roots, beans, seeds and nuts. There are two main types of flour from cereal (example wheat, corn, rice) a) the whole-grain flour where endosperm, germ and bran is together and b) the refined flour where it is only the endosperm. The composition of flour contains carbohydrates major part consist of starch (Sjöö, 2018). Starch is a source of carbohydrate. It has two main polymers amylose (AM) and highly branched amylopectin (AP). Starch plays a very important role in gelatinization when heated is applied parallel with excess of water (>1:2 starch: water) (Waterschoot, 2015). The phenomena of gelatinization is when the starch granules take up water and swell irreversibly upon heating, and the organized granular pattern is disrupted (Chen, 2015). The rest of components are lipids, protein (example gluten), fibre and moisture (Sjöö, 2018). A visual comparison and representation of brewer's grain flour versus wheat flour (see figure 12) (Ktenioudaki, 2012).

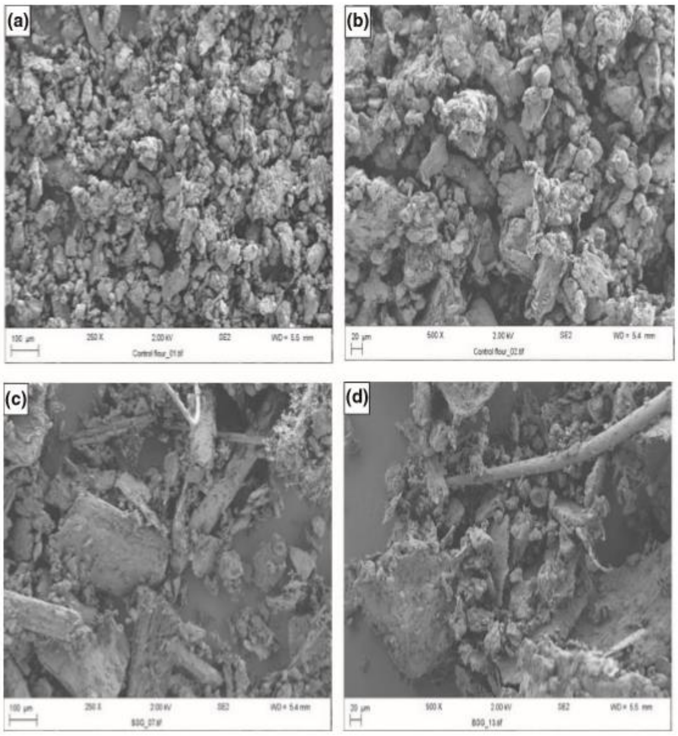


Figure 12: Microscopy of (a, b) wheat flour, (c, d) brewer's spent grain flour (Ktenioudaki, 2012)

Wheat flour

Perhaps is the most known and important type of flour throughout the ages for the majority of the bakery products. The wheat flour that is used is refined and contains major part of the endosperm. It has different classifications according to gluten strength. Weak flour has 7-9% of gluten and strong flour has 9-11% of gluten. For biscuit making usually the gluten content has to be low and the role of protein is not crucial. However, the protein content in wheat flour is moderate high. Finally, wheat flour provides to the biscuit dough a) formation during mixing and holding capacity of the various ingredients b) if the product is fermented (example bread) it helps holding the gases c) helps to form the structure of the biscuit (Zhou, 2014).

Some importation characteristics for flours are the water absorption index (WAI) and swelling power (SP) can be used as indicators in the thermomechanical treatment. The WAI measures the volume that the starch granule occupies after swelling with plethora of water and the SP is the ratio of weight of the wet sediment to the initial weight of dry starch. The factors that influence the WAI are the starch, proteins, pentosans, vital wheat gluten and other ingredients that are in favour of binding with water like fibre, eggs, bran and hydrocolloids (BAKERpedia, 2019). Gelatinization is mainly influenced by the amylose/amylopectin ratio (Rodriguez-Sandoval, 2011). Gelatinisation of starch is characterised as complete when the highest temperature is recorded (Sjoo, 2018). Wheat starch morphology can be described as round with lenticular shape (Waterschoot, 2015).

Rice flour

The origin and etymology of rice exists since mid-13 century. Derives mainly from Greek *oryza* but also Old French *ris*, Italian riso, Latin *oriza* (Online Etymology dictionary, 2019). Scientific name of rice is *Oryza sativa L.* and it is an important grain (Zhou, 2014) Rice cultivars have exceed 2000 new cultivars around the world (Wani, 2012). Rice morphology of starch is very small polygonal granules (3-8um) (Waterschoot, 2015).

Rice grain needs to be grinded and refined into flour for baking. Baking with rice flour requires different handling from the rest of them because the protein content compared with wheat flour is lower. Rice nutritional composition it is affected by cultivar, environmental and processing variabilities. Blends of rice and wheat flour has been used for biscuit production usually the used percentage of rice flour is up to 20%. The mixer of wheat and rice gives the desired characteristics for the biscuits (Rossel, 2014)

Potato flour

Potatoes (*Solanum tuberosum*) are the 4th most produced food crop after wheat, corn and rice. Nowadays potato flour due to its wide range of usages has become a good value-added ingredient especially when there is a need for a thickener agent and colour or flavour improver. When in use of potato flour in a bread recipe it is advisable to use less than 10% (Rodriguez-Sandoval, 2011). Potato starch are very large, round or oval granules (10-100um) (Waterschoot, 2015).

Corn flour

Corn is also known as maize (*Zea mays*). Corn in rich in anthocyanins and phenolic compounds having antioxidant and bioactive properties. Corn is used as a mixture of flours is different compositions. For instance, for bread making is used up to 50% of corn flour mixed with rice or wheat (Zhou, 2014). Corn starch granules are polygonal (Waterschoot, 2015).

2.4.2 **Baking process**

The category of biscuits are made primary with wheat flour, sugar, fat and other ingredients. The process that is followed is described in the figure 13. The process might have more sub-stages depending of the type of biscuit and the chosen process.

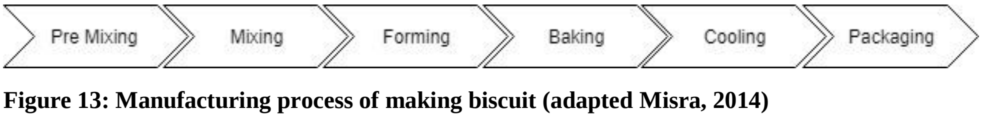


Figure 13: Manufacturing process of making biscuit (adapted Misra, 2014)

2.4.2.1 Mixing and dough making

After weighing the ingredients, the first step into the creation of dough is mixing. Mixing has the most significant part in the baking process. It has to be performed correctly otherwise the next steps cannot be completed or misbehaviour of the ingredients will rise. Control over the mixing step is mandatory. Objectively, it is not easy to have the same outcome every time you perform a dough process therefore you need to be precise with scaling the ingredients, mixing phases and time, type of equipment and temperature (Haegens, 2014).

Dough has unique preparation technique when yeast is present, as well as when salt is added. When salt is added the dough will start pushing water out resulting in a "watery" dough. Mixing assist to homogeneous incorporation of ingredients, hydration of flour with the rest of dry ingredients and development of gluten network (Haegens, 2014).

The stages that affect mixing time can grouped is 3 categories. Category 1, the ingredients "first meeting", when the ingredients come together are cold and chunky later as the mixing continues they warm up and become smoother and drier. Category 2, "getting together", the ingredients have blend and the dough is at maximum stiffness. The temperature and knobbing quality as well as the gluten network is at the appropriate state. Category 3, "separation phase", when the mixing time is surpassed the dough becomes sticky with too much elasticity and becomes to dissolve (see figure 14):

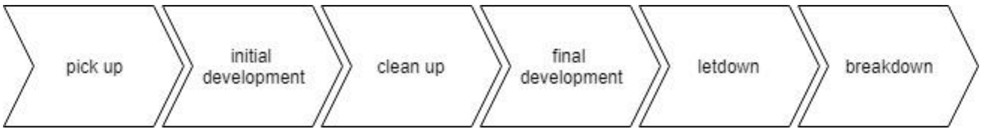


Figure 14: Mixing stages (amended, Haegens, 2014)

Factors that are affecting the mixing time of dough:

- Mixers': speed, design and cooling system
- Dough's: size and temperature
- Ingredients: flours quality and water activity, shortening, reducing and oxidizing agents
- The analogy of dry and solid ingredients competing with water (Haegens, 2014)

There are few types of mixers spiral, fork, artfex and vertical (hook). In this project, vertical mixer is used for biscuits. Regardless the type of mixer, the goal is always the same, homogeneous dough and the creation of gluten network and gas retention (Haegens, 2014).

2.4.2.2 Baking

Baking has two main "actors" performing simultaneously, one is the applied heat and the mass transfer from and to the product (Misra, 2014). The simplest oven is a heated box with a door. In industries the used ovens are tunnels various sizes and bands. The types of ovens in industrial-scale are gas fired, oil fired and electric. The type of bands are plenty but for biscuit is recommended the wire mesh. The transport of heating to the biscuits are conduction, convection and radiation. Heat and temperature are not the same. Heat it can be measured because it is energy. The change at the temperature (℃) comes from the alteration in heat. A schematic representation of the heating transfers are presented below (see figure 15) (Manley, 2011 and Misra, 2014)

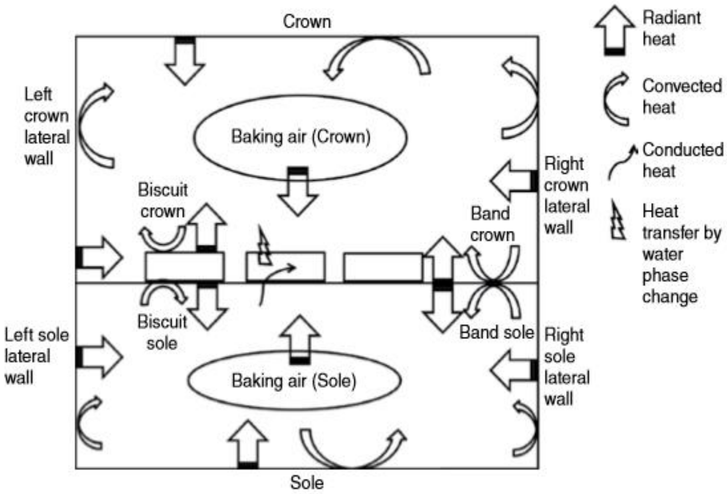


Figure 15: Cross section of a biscuit baking in oven with different modes of heat (Manley, 2011)

According to literature the average time of baking biscuits ranges between 2.5 to 15 min with a mean of 6 minutes. But this can change quickly in a static oven versus industrial. Therefore, experimentation is need it to define the precise baking time. Often baking is been described as black art (Manley, 2011).

During baking the main changes that influence the final biscuit are the product density reduction, drop of moisture levels to 1-4% and change in colour (Purlis, 2014). Dry pet food has an average moisture content below 10% (Guy, 2016). After baking there are some reactions (physical, chemical and biochemical) that happened in the baked biscuits. The main ones that are explained in detailed are the Maillard reaction or browning and the water loss. Caramelization and Maillard reactions gives to the biscuit body the colour and flavour according to temperature, water activity and pH. When the sugars are reduced and the protein and amino acids heated Maillard is occur whereas the Caramelization happens when carbohydrates are been heated (Manley, 2011 and Purlis, 2014). A graph represent the food reaction of the dough while is baking. Starch gelatinization and gluten coagulation at 75 degrees, creation of biscuit body at 100 plus degrees and caramerization starts at 130 degrees (see Figure 16)(Manley, 2011).

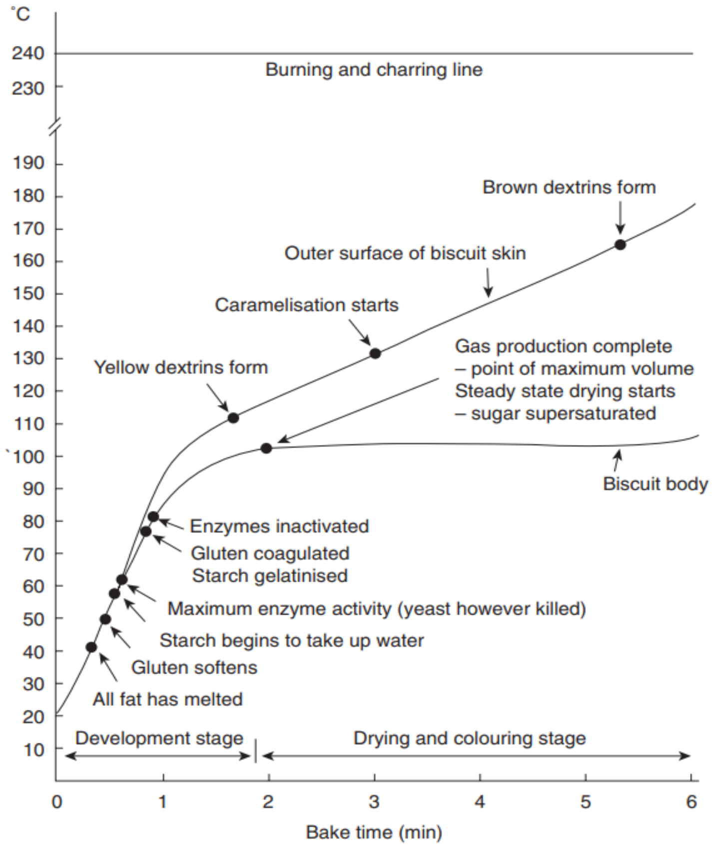


Figure 16: Changes during baking (Manley, 2011)

Cooling and packing steps ensure that the product will be eliminated from microbiological spoilage due to low moisture content thus brings long-self life but also protection from up taking moisture. When looking at the packaging it needs a protective layer against oxidation in the primary packaging material (Misra, 2014).

Quality control of biscuits happens at an industrial level. Ingredients (flour, sugar and fat) and processing conditions (mixing, molding, baking and cooling) are important factors for controlling the consistent quality of the produced product. Interactions between the above parameters can be predicted by test-baking. Analysis such as moisture content, texture, colour of biscuit were been used in this thesis project. Other analysis exists such as acidity, pasting properties, density, dimensions and biscuit ratio but are not considered (Misra, 2014).

3 Materials and Methods

This chapter describes the experimental process that was followed for formulating the dog biscuit the material used and the baking process.

3.1 Initial products' specifications

To begin this project it is needed to be set a rough sketch of the products specification so when the trials are taking place the document will change along the way. Therefore, the frame of categories for the products specification are:

Product concept: A sustainable complimentary dog snack for all dog ages. Planet-friendly. Sustainability 100%, meatless, simple ingredients, pet friendly, consumption under supervision and upon owner's decision according to the dogs' nutritional intake.

Product qualities: From the nutritional aspect the product has high protein and fibre content. The acceptance testing is part of the sensory analysis. The physical shape of the biscuit is small 2 cm length and 1.5 cm width in a shape of dog bone.

Products' stability is determined through aw and moisture content. The processing is happening through mechanical treatment of wet spent grain and the ingredients for the dough formation and applied heating for baking. The desired storage length needs a self-stable environment for the product. For the price length the ingredients and the sustainability will be taken into consideration. The targeted buyers are the dog owners with environmental consensus and the consumers are the dogs.

Through projects' scope, benchmark and literature each ingredient brings a role in the formation of the biscuits therefore an initial basic approach is with wet spend grain to provide structure various flours for the dough formation, crispy texture, egg act as a binder and boosts the nutritional composition with protein, type of extract for flavour, type of fat to enhance the palatability and texture.

The process is as follows: Obtaining the beer by-product (wet spent grain) from the local craft brewery, trials of baking and formulating in the kitchen lab. The desired formulation will have optimum 70% utilization of wet spent grain. The packaging will be in a paper or plastic (laminated or not) bag with a capacity of 250g.

All the process is in compliance with government legislation and European commission. All the used ingredients are listed in the Appendix L from the European legislation of directive 82/475/EEC. According to the nutritional European Pet food Industry Federation (FEDIAF) guidelines, the EU food law paragraph IV on complementary dry dog food were taken into consideration (FEDIAF, 2017). The marketing plays a crucial role in the development and claiming titles that are current a trend in the market place therefore, product developers need to partner up with the marketing team to create a desired product (Passport, 2017).

3.2 Material used

Benchmarking of commercial dog snacks from various pet stores and retailers in Lund. Researching on brew dog biscuits worldwide shows a pattern of frequently used ingredients, the analytical composition (see appendix A). A summary of the used ingredients in a dissenting order of commercial dry pet snacks are meat and animal derivatives, cereals, (sometimes cereal is first, indicating that the majority of the product is cereal based) followed by fat and oil derivatives, supplement additives, preservatives and colourings (see appendix A, column 'analytical constituents'). Looking at the brew biscuits (see appendix A, line 12-16, column 'ingredients')we can see that the first ingredient is spent grain or wheat flour, eggs or meat and flavours.

3.2.1 **Wet Spent Grain**

The wet spent grain is the main ingredient of the dog biscuit as it is rich in 20% protein and 70% fibres (Galanakis, 2018). It is a very moist ingredient. Different cookies recipes from brewers' grain suggested. As a first step was to dry the grain and then incorporating in a form of flour in the recipe. However, this procedure is not energy friendly since it requires the drying of wet spent grain. Recipes with wet or fresh wet spent grain were limited to homemade amateur videos and sites which plenty of them were not very reliable. Recent study shows that that maximum wet spent grain in a biscuit recipe was up to 50% (Petrović, 2017). On the other hand, there were spent grain treats or biscuits in the market and the ingredient list helped us. Pointing out that the wet spent grain is a beer brewery by-product that waits to be rotten with all this nutrient still on it.

3.2.2 **Flours**

Flours were the second in weight ingredient that was incorporated in the recipe. Due to its different water absorbance capacity of different flours a table was formed to display which one has good behaviour combined with the wet spent grain. From various literature sources that can be seen in table 3 the water absorbance index and the protein levels from each flour can be seen.

Table 3: Different flours and their characteristic (reference in the boxes)

Flour	Moisture content (%)	Water absorption index	Swelling power (SP)	Starch Gelatinization (52-99°C) (Manley 2011)	Protein (%)	Starch (%)	Lipids (%)
Wheat	12.57 +- 0.28 (Rodriguez-Sandoval, 2011)	1.92+- 0.06 (Rodriguez-Sandoval, 2011)	1.96+- 0.07 (Rodriguez-Sandoval, 2011)	67.5 °C complete gelatinization (Sjoo,2018)	12 (Sjöö, 2018)	63-72 (Sjöö, 2018)	2 (Sjöö, 2018)
Rice	11.67+- 0.62 (Wani, 2015)	1.94+- 0.09 (Wani, 2015)	(55 °C) 6.41 ± 0.6 to (95 °C) 19.0 ± 0.5 g/g (Thiranusornkij, 2018) (95°C) is 17.58% (yadav, 2016)	55.0 °C complete gelatinization (Sjoo,2018)	8.86+- 0.87 (Wani, 2015) 4,5-15,9 (Sjöö, 2018) 6.3 to 7.1 (g of N × 5.95) (Zhou, 2014)	90 (Sjöö, 2018) 80% (14% moisture) (Zhou, 2014) 77.17+- 1.3 (Wani, 2015)	depending on bran layers and the milling process (Zhou, 2014) 1.73%-1.13% (Puri, 2015) 1.99+- 0.07 (Wani, 2015)
Potato	11.57+- 0.98 (Wani, 2015) 15.35+- 0.72- potato starch (Yadav, 2016)	1.81+-0.4 (Wani, 2015) 75.06+- 8.53 % -> starch not flour (Yadav, 2016)	(55°C)to 33.41% (95°C)	62.5 °C complete gelatinization (Sjoo,2018)	8.86+- 0.87 (Wani, 2015)	90.40+- 0.15 (Yadav, 2016)	
Corn	12.03 +- 0.19 (Rodriguez-Sandoval, 2011) 11.57+- 0.98 (Wani, 2015)	4.48+- 0.11 (Rodriguez-Sandoval, 2011) 1.81+-0.4 (Wani, 2015)	4.84+- 0.12 (Rodriguez-Sandoval, 2011)	62.5 °C complete gelatinization (Sjoo,2018)	8.4-9.5% (Zhou, 2014) 8.86+- 0.87 (Wani, 2015)	73-78% (Zhou, 2014) 71.82+- 1.54 (Wani, 2015)	1.2-4.3 % (Zhou, 2014) 4.32+- 0.13 (Wani, 2015)

3.2.3 **Whole Eggs**

Egg has high nutritional value even for dogs. Therefore, is added to the formulation for raise the protein content of the dog biscuit and adding flavour (Zhou, 2014). The whole egg that was provided was in the form of powder with 47% protein content and fat content of 42% with moisture content of 4% (technical data sheet).

3.2.4 **Rapeseed oil**

Is part of the lipid group of macronutrients and according to 2007 Swedish agricultural data sheet the production of rapeseed is produced mainly in the southern part of Sweden (Jordbruks verket, 2009). Rapeseed oil will contribute in the cohesiveness and structure of the dough (Zhou, 2014).

3.3 Recipe Formulation

Before forming the dough and baking the biscuit. The process of designing the trials and the outcomes for forming the dough and baking the biscuits are shown below (figure 17). The part 1 has the benchmarked dog products that are in the market (see Appendix A, column 'brand'), the conducted interviews with various actors within pet industry as well as pet store retailers (see Appendix B) from literature review and regulation there is the most common pet food ingredients (see Appendix G and L). Part 2 occupies the designing of the trials and sets the scope and the method that will be followed, part 3 is the actual baking in the kitchen lab and part 4 the record data receiving feedback. According to the outcome and the aim that was set either the experimentation stop there or the designing process starts again from part 1 (see Figure 17)

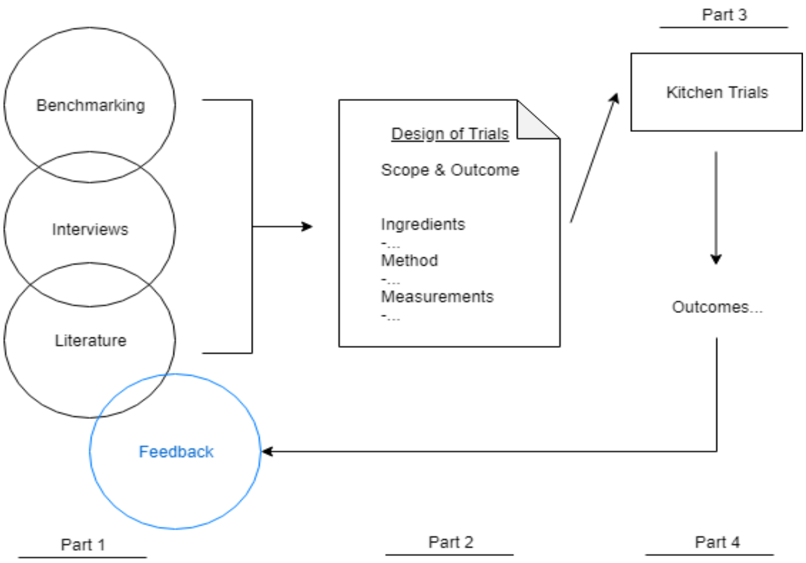


Figure 17: Design the process flowchart of dog biscuit

The wet spent grain is obtained from the brewery right after the lautering phase (Galanakis, 2018). The wet spent grain is transferred to the kitchen lab and store in the fridge (at 3°C). Once it is time for baking the ingredients are prepared in room temperature. A schematic representation of the process is described in figure 18.

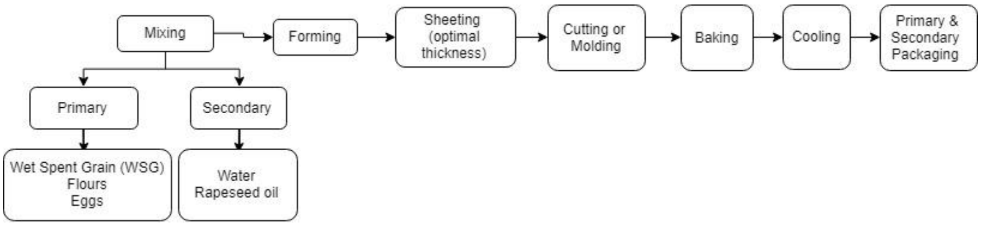


Figure 18: Process flow chart for creating biscuit

The ingredients that were used in the formulation of the dog biscuits are different types of flour (potato, rice, wheat, corn) and rapeseed oil purchased from local supermarket, whole egg powder provided by a Swedish company, the wet spent grain was offered by Brygghuset Finn brewery. As it shown in the figure 19 the ingredients for the dog biscuits.

Figure 19: Ingredients used for the formulation of the dog biscuits

The ingredients were measured and the mixer used (model: Artisan, KitchenAid, Model Name 5KSM175PS, flat mix) for mechanical steering until the dough is formed and it is detachable from the walls of the mixer bowl (Figure 20).

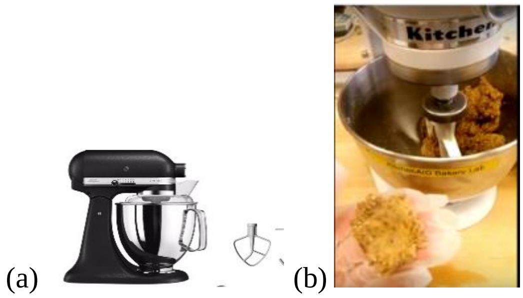


Figure 20: (a) Used mixer for dough homogenisation (b) and the final visual of dough in the mixer before the sheering, cutting and moulding

Then apply rapeseed oil with a painting brush in the baking sheet and place the dough in between. Open the dough with a rolling pin and shape the cookies. Preheat the oven at 125°C temperature and place the tray with grids with a baking paper in the oven with the biscuits on top. Bake until the temperature inside the dough is beyond the gelatinization point of the flour. Then wait to cool down and start the measurements (Figure 21). Several recipes were formulated and the ingredients are been chosen according to the estimated commercial properties which are described in the next paragraph.

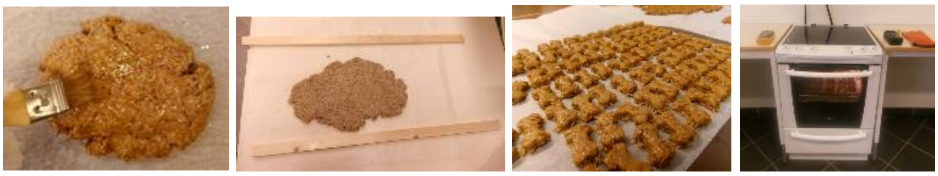


Figure 21: (a) dough at baking sheet and oil applied with brush, (b) dough height standardized with the wooden sticks and the rolling pin, (c) dog biscuits placed in the baking tray (d) equipment used for baking the biscuits and thermometers

3.3.1 Physical characteristics of dog biscuits

According Adeola, 2018 adjusted to my research to evaluate the dog biscuit the physical, sensory characteristics are presented here.

- Thickness of biscuits was determined by measuring the thickness of 4 commercial biscuit (see Appendix A line 10-13), samples placed side by side measured with a calliper. An average of four values was taken for each biscuit. The final thickness is documented in centimetres and the medium that selected is 0.6 -0.8 centimetres (cm).
- Diameter of biscuits was determined by measuring the length of each biscuit with a calliper. An average sample of 4 was documented and the medium that was selected is 2.0 -2.5 cm.
- Weight of biscuits was measured on average of 4 commercial biscuits using a weight scale (model: PB1502-s Metler Toledo). The weight is documented in grams (g) and the selected weight is between 2- 3g.
- Shape of the biscuit was created taking into consideration the consumer preference (dog owners) for dog snacks as well as the best selling products from the 4 pet shops in Lund (Guy, 2014). The shape of cookie cutter was draw on AutoCAD and 3D printed in the department of Design Centre (Figure 22).

Regarding the material that was used had to be polished in order to be acceptable for food consumption.

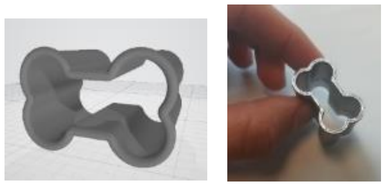


Figure 22: 3D animation of bone shape cookie cutter metallic material used

- Texture analysis of dog biscuit samples in toughness using the texture analyser (model: TA-XT2i texture Analyszer by Stable microsystems). The analysis was set to perform single measurements which it imitates the force of the first bite of the biscuit according to pet food principles. The mean was documented from 4 commercial samples.
- Colorimetry CIELAB of biscuit was documented by measuring the L*, a*, b* of 4 commercial samples. For each tested recipe from the trials ΔE value was measured having as a control sample the variables form the commercials samples (see Appendix M). The selection of the appropriate recipe has the lowest value of ΔE compared with the commercial (model: Spectrophotometer CM-700d/600d).

The levels of aw and moisture content were taken into consideration of the final product to be safe for consumption. Water activity and moisture content are monitored because they are self-life attributes (Nielsen, 2010). The a_w measurement was conducted by measuring the baked product after 45 minutes and the result were recorded. The measure of moisture content is been done by using the humidity oven standardized in 104 degrees Celsius over a period of 12 hours.

3.4 Baking

The oven that was used is a simple electric oven with door (model: ELEKTRO HELIOS SPIS, SK7604) located in Kitchen Lab at the Kemicentrum. Temperature was measured with digital thermometer (model: CIE 307 - 2 Channel Temperature Meter). The dog biscuit was baked in temperature outside of the product at 130 ℃. According to literature, the baking time was more than 15 min (Manley, 2011). The cooling stage occurs after the baking and the dog biscuits left to cool down in room temperature. Then measurements of water activity, moisture content were taken for quality control check.

3.5 Consumer Approach

In order to check if the product is acceptable by the dogs and the dog owners a series of interviews was scheduled. Initially, a poster was created with the aim to find people who had dogs (Appendix K). That was a very challenging part. However, when dog owners express their interest in participating with their canine companions the first meeting was scheduled and the consents forms along with instructions were communicated (Appendix H and I). After 5 days a personal meeting was scheduled for feedback and an interview was conducted to discuss the audio-visual material of our canine friends (Appendix J). Finally, the dog owners and their dogs that where interviewed can be seen in Appendix C. Some of the dog owners had in their custody more than 1 dog.

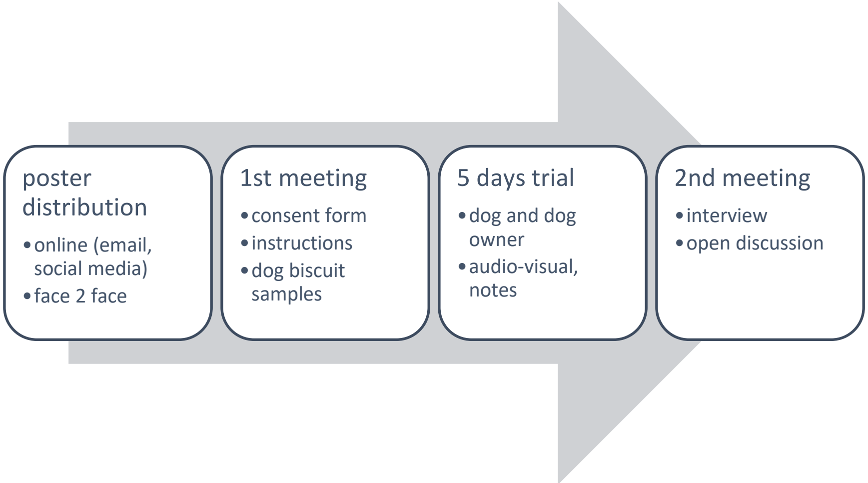


Figure 23: Steps for conducting dog testing

4 Case of Craft brewery

It is presented and discussed the state of a business challenge that craft breweries are currently facing. Due to the nature of the project an interview is conducted to a Swedish craft brewery to enlighten us with the situation. The focusing point will be to describe the current approach when it comes to wet spent grain disposal. How it affects the brewery financially and propose an alternative solution. Initial information about Swedish brewery are presented in paragraph 1.2 also the general steps in order to make a beer are presented in chapter 2.3.

4.1 Current disposal of the wet spent grain

As it is described in chapter 2.3 the brewing process starts from the mashing stage when the malt is grinded. Then in the lautering phase water takes up all the starch from the grain and when the wort leaves the lautering tank the wet spent grain is obtained (Mosher, 2017). During a visit to the local brewery the figure 23 captures the time when the wet spent grain is been removed manually and thrown in the container to further be relocated from the manufacturing area outside of the brewing facility.

Over time they had tried different ways to sustainably recycle the wet spent grain. For instance, through local farmers as an animal feed specifically for cattle. However, due to short self-life of the brewers’ waste and unstable material transport it did not last over time. Currently, the wet spent grain is collected by a food waste company. It is thereafter to be converted to biogas and after enters the facility in a form of energy or heat. The services of collection and biogas conversion are paid repeatedly and is a financial inconvenience for a small craft brewery (Appendix-B, interviewee 4).

Figure 24: Wet spent grain is removed after mashing stage (Appendix-B, interviewee 3)

4.2 Analysis of the case problem

The sustainable development goal Nº12 is focusing on food waste and sets a target by 2030 to reduce it along its production, supply chains together with post-harvest losses. The circular economy tool aligns exactly with the food waste target (Unger, 2018).

Sustainable beer brewing process is gaining more and more attention and industrial breweries are trying to find ways to integrate their waste for this purpose (Passport, 2018). At the same time, annually, craft breweries are paying 1400$ - 18000$ (1,254.41 € to 16,128€) for their solid waste to be disposed (Stier, 2010). Currently the produced wet spent grain from the brewery range from 450-800 kg per batch and day. In 2018, the beer production rose up to 200 thousands litres (Appendix-B, interviewee 4) and according to North European and Nordic crop data base the malts in 2018 have 25-30% higher protein content.

According to customer orders the grains that are used are mostly barley 80%, a little bit of wheat, oats and rarely rice. The malts are been purchased from Sweden and other countries nearby. When the mashing is happening the grains come out of the tank in a temperature of 70℃ and the most efficient temperature to proteins denaturation from the malts are above 50℃. The higher the mashing temperatures the more sugars are released in the wort and none in the grain. Proteins make the beer hazy and sediment on the bottom. This is not desirable when beer making. Therefore, when beer is manufactured they try to leave as much protein as they can in the grains and by doing this the throw away an ingredient that could easily be integrated in the food chain while it does not (Appendix-B, interviewee 4).

4.3 Future steps

According to food waste recovery scheme, craft breweries are in search for a new sustainable and economical friendly approach without deteriorating the soil through landfill, composting and industrial uses. The question about what should be done to reduce food waste in the beer brewing section is debatable. However, a proposed scenario could be a possibility on creating a cluster of all beer brewers in local area collecting all the wet spent grain without charge and recreating a complementary food for animals and more specifically for canines. This, however, comes with various risks. For instance the parameters of transportation, logistics market segmentation and product acceptance and many more. To be more specific, a business strategy is vital to be explored. This master thesis offers an opportunity to eliminate this problem by having as a goal to upcycle the wet spent grain by developing a complementary biscuit for our canine friends.

5 Experimental Findings

In this chapter the findings from the experimentation in the Kitchen Lab are presented and also the interviews with the dog owners.

5.1 Trial 1 – Initial attitude of Brewers' Grains

The aim of this trial was to explore the nature of wet spent grain by incorporating rice flour. The motivation behind the usage of rice flour is that the protein content of rice flour is low (table 3). There is low percentage (%) of gluten network resulting in a wide range of consumers with allergic dogs. Also, the wet spent grain has no detectable percentage of starch (Sjoö, 2018). Therefore, it makes the ultimate ingredient for allergic or dogs with gluten intolerances. Starting this step was difficult because from the primary research there was not any formulation in creating biscuit (or any kind of cracker) from fresh brewer's waste for canine consumption. The experiment showed that the use of 100% wet spent grain is not feasible of making biscuits. Incorporating 10% of rice flour the creation of dough is not in the levels of mouldable and functional. By placing 30% of flour the wet spent grain does not give us the desirable dough characteristics. The best combination was 50% of wet spent grain and 50% of rice flour and the optimum dough that have been accomplished. A visual representation of the analogy between wet spent grain and rice flour can be seen in table 4.

Due to high moisture content of the wet spent grain our first hypothesis, which was to utilize 70% of wet spent grain, is not feasible with the presence of rice flour only. The usage of one single ingredient is not enough to integrate the wet spent grain in a sustainable manner therefore, in the next trial the incorporation of different type of flours as well as the two functional ingredients which are oil and eggs will be conducted with the aim to increase the content of wet spent grain.

Dough Results	Dough Results
	
100% wet spent grain and 0% rice flour	90% wet spent grain and 10% rice flour
	
70% wet spent grain and 30% rice flour	50% wet spent grain and 50% rice flour

Table 4: Wet Spent Grain and Rice analogy a visual representation

5.2 Trial 2 – Getting to know Brewers' Grains

The two ingredient formulation (wet spent grain and rice flour) from trial 1 was enriched with rapeseed oil and egg. These two ingredients gave the desired connectivity for dough functionality and cohesiveness, moulding and baking activities. At the same time the analogy of wet spent grain and flour from the trail 1 stays at the same levels. This results in minimizing the usage of rice flour and maximizing a tiny bit the used wet spent grain. With the trial 1 and 2, the question of how the other types of flours are behaving towards wet spent grain still remain and the next step is to investigate the effect. Since the wet spent grain is 75% moist by trying different flours which have different levels of water absorbance (see table 3). The outcome and the scope for the next trial was to investigate which flour had the minimum amount in the recipe with the wet spent grain while the incorporation of wet spent grain is at highest levels.

5.3 Trial 3 – "Decoding" formulations in texture and colour

Following up from trial 2 in this trial five different formulations (see table 5) were tried out having different analogies of flours and egg. Knowing that texture and colour features are important for the commercial treats the aim was to see if the commercial features are in line with the proposed formulations and at the same time try to increase the percentage of wet spent grain.

Table 5: Trial 3, formulations

Ingredients %	**A**	**B**	**C**	**D**	**E**
WSG	54.1	48.8	52.6	51.8	51.3
Wheat flour	21.6	7.3	5.3	6.2	17.9
Corn flour	10.8	-	-	29	5.1
Potato flour	-	31.7	-	-	-
Rice flour-	-	-	28.9	-	-
Egg powder	6 (12%)	6 (12%)	6 (12%)	6 (12%)	20.5
Water	6	6	6	6	-
Rapeseed oil	2	2	2	2	5

The formulations of D (6% wheat flour and 29% corn flour), B (32% of potato flour and 7% wheat flour) and E (18% of wheat, 5% corn flour and 20% of egg) have their values close to the colour difference from the commercial dog treat (ΔE). The ΔE is below 10 points for all the formulation (see Appendix M1). From table 6, the formulation B has lightness (L*) value close to the Eldorado-kaustange commercial treat whereas the formulations A and E have the colour channel for green-red values (a*) close to Eldorado-kaustange and puppy treats. From table 6 the water activity (a_w) of the formulations are within a_w range of the commercial dog treats. The moisture content of formulations varies and the cause is the uneven width of the dough.

Table 6: Measurements of colour, aw, moisture, total solids for commercial treats

Commercial Dog Treats	**Colorimetry**			**a_w**	**Moisture %**	**Total solids %**
	L*	**a***	**b***			
Eldorado-Kaustange	58,9±0,6	7,84±0,3	24,35±0,9	0.351	7.8	92.2
Eldorado- Puppy treats	56,97±2,2	8,31±0,4	24,69±0,8	0.380	6.3	93.7

Dogman- Klassiskt	43,37±1,6	7,14±0,4	18,43±1,1	0.500	8.8	91.2
Specific-Healthy treat	43,42±5,3	7,28±0,9	23,73±1,7	0.355	7.1	92.9
Formulations						
A	21,87±6,9	7,68±1,2	26,11±3,5	0.368	4.3	95.7
B	57,13±15,3	5,56±0,9	18,91±0,9	0.363	7.8	92.2
C	62,61±4,3	3,97±3,5	19,55±3,7	0.437	16.1	83.9
D	61,52±9,5	4,91±3,1	21,68±1,6	0.541	20.5	79.5
E	37,49±14,2	8,8±0,9	22,55±5	0.456	17.2	82.8

When the texture analysis is examined, two formulations were in same force levels compared with the commercial treats and those were A (21% wheat flour and 10% corn flour) being close to the commercial 2 and D (6% wheat flour and 30% corn flour) being close to commercial 3(see table 7). The displayed samples were analysed 12 times and the standard deviation (SD) was placed. The force (kg) and the distance in time (figure 25) between the commercial and the formulation are taken into consideration when examined which formulation from trial 3 is closer to the commercial texture.

Table 7: Applied force in commercial and formulation god treats (Figure.24)

Name of dog snack	Force (kg)
Commercial 1- Dogman- Klassiskt	2.31±1,06
Commercial 2- Eldorado- puppy treats	4.70±0,58
Commercial 3- Specific- Healthy treats	2.95±1,26
B	3.32±0,75
A	3.50±1,43
D	2.71±0,79
E	2.68±1,28
C	2.07±0,84

From the graphical representation in texture analysis (Figure 24) shows that the commercial treat have a roughly linear cracking model rather than the developing formulation which are cracking in 2 or 3 steps before the actual cracking occurs. The anisometric cracking experience verifies that the structure inside the dog biscuit is not homogeneous. A simple explanation is that the fibres from wet spent grain are interfering with the cracking. Also the width of the developing biscuit is not the same centimetres and that could interfere with the time that the force is applied. The selected formulation compared with commercial are B and A being closer in time and distance when the pick of the breaking force.

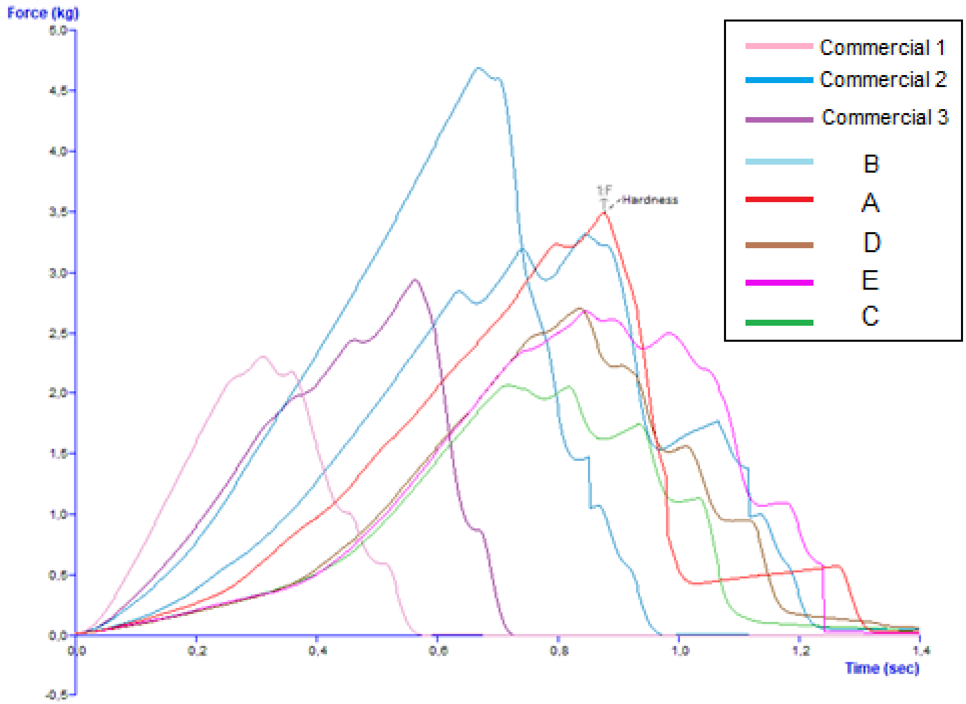
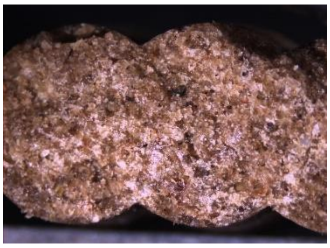


Figure 25: Texture analysis of commercial and the dog biscuits formulations

A visual structure of the formulations in comparison with the commercial treats (table 8) shows that there is a variety in the structure among the commercial treats being porous and condense. The formulation E is the most concrete followed by B and A. But, this is not objective since the interpretation varies.

Commercial treats		
Dogman	**Eldorado- Puppy treats**	**Specific- Healthy treats**
		

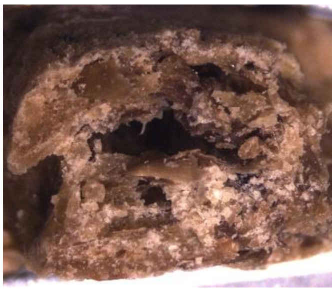
Formulation of Dog Biscuits		
A	**B**	**C**
		
D	**E**	
		

Table 8: Visual structural profile of commercial treats and formulations of dog biscuits

The baking process as far as the temperature profile of the formulation went in a predictable way (see figurer 25). The creation of the biscuit body and the baking time is happening after reaching 100℃ (Manley, 2011). The baking time in constant temperature of 120℃ happens for a time frame of 45'. It is verified that the temperature profile of proposed formulation have the same behaviour as far as a temperature profile like a tunnel oven performs the baking process (figure 26 and figure 16).

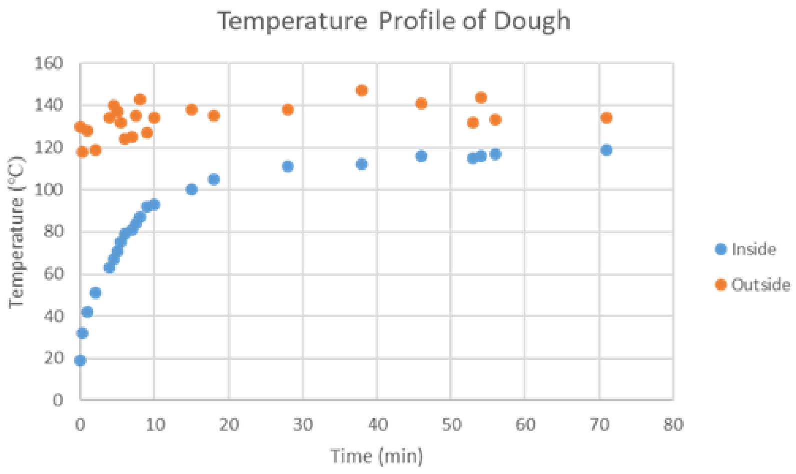


Figure 26: Temperature profile of Dog Biscuit

5.4 Trial 4 – The unexpected situation of Brewers' Grains

A repetition of trial 3 was conducted in order to select a formulation (see table 5). The unexpected outcome was that by comparing colorimetry and texture between commercial and formulations there was not any comparison that could link the results from trial 3 with trial 4.
The colour difference (ΔE) of the formulations A, B, C, D and E are giving different values from the trial 3. However, the formulations B (7% wheat flour and 32% potato flour) and C (30% of rice flour and 5% of wheat flour) are close to the ΔE values of Specific-Healthy treats and the Eldorado-Kaustange commercial treats (see Appendix M). However, the ΔE is beyond 10 points from the commercial treats. Moreover, the lightness (L*) from the formulations are not in close range with the commercial treats (table 9). The formulations A (21% wheat flour and 10% corn flour) and C with the colour channel of green-red values (a*) are close to Specific-Healthy treats and the Eldorado-Kaustange commercial treats.

Table 9: Measurements of colour, aw, moisture, total solids for commercial treats

Commercial Dog Treats	Colorimetry L*	a*	b*	a_w	Moisture %	Total solids %
Eldorado-Kaustange	58,9 ±0,6	7,84±0,3	24,35±0,9	0.351	7.8	92.2
Eldorado- Puppy treats	56,97±2,2	8,31±0,4	24,69±0,8	0.380	6.3	93.7
Dogman- Klassiskt	43,37±1,6	7,14±0,4	18,43±1,1	0.500	8.8	91.2

Specific-Healthy treat	43,42±5,3	7,28±0,9	23,73±1,7	0.355	7.1	92.9
Formulations						
A	20.77± 5,8	7.30±1,4	26.70±4,5	0.253	5.9	94.1
B	31.55±13,8	5.68±0,8	21.02±1,0	0.228	9.5	90.5
C	32.12±17,9	7.53±2,2	27.61±4,1	0.178	5.5	94.5
D	26.14±8,4	6.26±1,0	23.27±2,7	0.183	3.4	96.6
E	31.19±15,3	9.37±1,7	28.99±6,0	0.344	9.5	90.5

For the texture analysis one formulation had the same force levels compared with the commercial-3 treat and that was E (18% wheat flour, 5% corn flour and 21% of egg). The displayed samples were analysed 12 times and the standard deviation (SD). The force (kg) of E is 2.91 and the commercial is 2.95 very close in range (see table 10). From the graph (Figure 27) also shows that the formulation B, E, A could also be acceptable because the time space on the time of cracking is close to the commercial as the difference lies upon the difference on milliseconds. However, if the pick of the force is considered then B and E are considered. The texture profile for the trial 4 had total time of baking the same as the trial 3 which is 45' for 120℃.

Table 10: Applied force in commercial and formulation god treats (Figure 26)

Name of dog snack	Force (kg)
Commercial 1- Dogman- Klassiskt	2.08±0,89
Commercial 2- Eldorado- puppy treats	4.67±1,35
Commercial 3 - Specific- Healthy treats	2.95±0,34
B	3.61±0,77
A	2.52±0,78
E	2.91±1,19
C	1.22±0,69
D	1.42±0,88

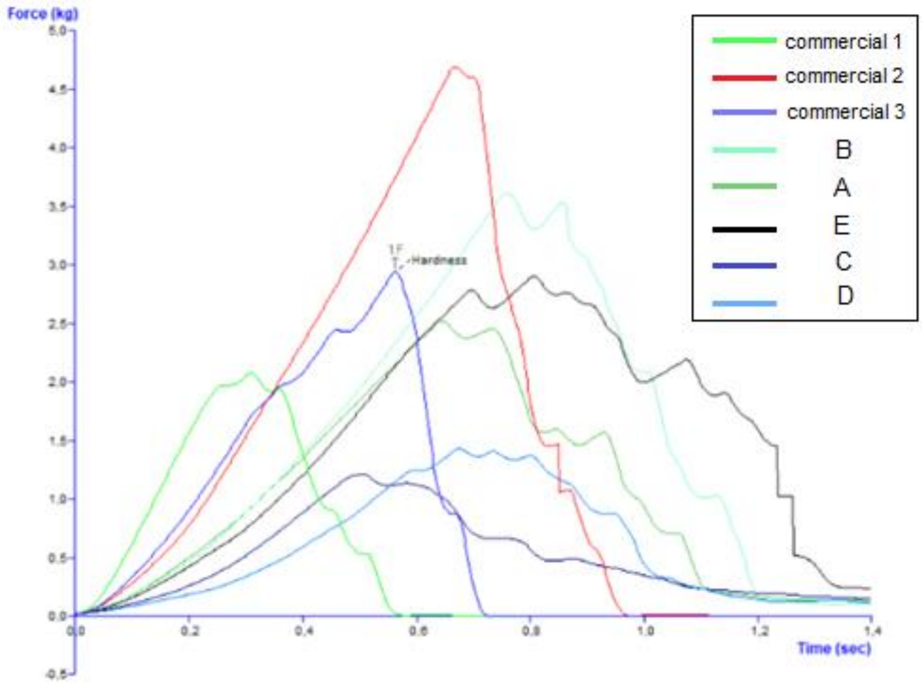


Figure 27: Texture analysis of commercial and the dog biscuits formulations

5.5 Interviews and trials with dog owners and their dogs

In analysing the interview data, two themes emerged which will be discussed in this section. These themes were: the complexity and the challenges of interpreting the visual actions of dogs consuming the dog biscuit and the dog owners' perspective about the dog biscuit.

For the dog owners feeding their dog with the biscuit is a familiar process which they know how their dog usually behaves when eating a treat (see Appendix E) although, there were some challenges identified. In the interviews (see Appendix C) some owners were knowing very well how their dog behave and their feedback was accurate however it comes in contrast with the duration that the dog actually manage to eat the treat.

Dog owner 2 said that:

"...one of the dogs (D) when she saw the candy was like sniffing a bit and then took them off on the floor and then she went back and ate one at a time and in the first day the other dog (E) ate both of them straight from your hand but in the second day ...he (E) was picking them from the hand putting them on the floor and then ate them it took them more time to eat the candy compared to cheese…"

Also when the Dog owner 3 was interviewed it was observed that the duration of consumption of the biscuit was longer due to biscuit crumbles. More specifically, Dog owner 3 said:

"...when you train the dog you need very small pieces because you give them a lot...he (F) had a normal 'wagging' of tail and he eats them...he acts the same and he eats everything...as I saw he reacts the same as the commercial one...but if I smell yours the odour is not that strong...my dog is less picky because he doesn't eat treats very often so when I give him he can take whatever he can…"-

These comments seem to indicate that even though the dogs ate the dog biscuit in the end it took them more time in comparison with the commercial one. Firstly, they did not seem that the colour is an issue because even though the biscuit fell they pick it up and ate it. The odour plays an important role in the dogs regardless the result of the consumption and that can be justified not only from the literature but also from the trials (Li, 2017).

Now, according to the interview all the dog owners when were asked if they would purchase a sustainable treat were positive in this initiative (Figure 29) this comes in comparison with the results purchasing drivers where the price rank at high priority and then the used ingredients regardless if it was sustainable or not (Figure 28) along with that there is the attitude of dogs when they consume it that the need to be motivated over time to eat it and to 'earn' it and that came in confusing patterns over the audio-visual material that showed the dogs to eat the biscuit but took them time.

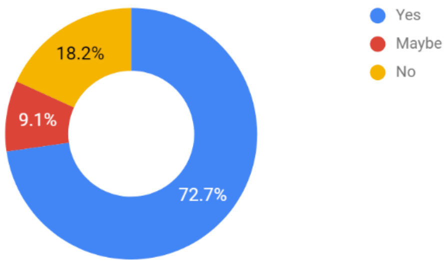


Figure 28: Prediction on purchasing the dog biscuit

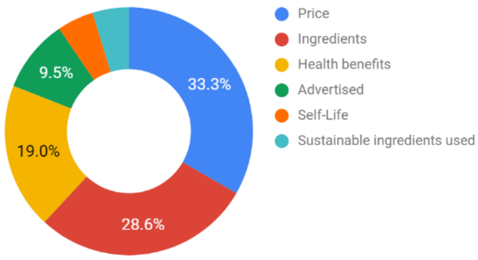


Figure 29: Purchasing drivers

Another driver that leads the owners perspective is the matter of shape and size. When they were asked on the overall perception of the dog biscuit the figure 30 shows that shape is a driver but also smaller size of the biscuit. Here it comes the positioning of the product which it is not included in this thesis. However, an estimation and a distiction between training treats and a snack (biscuit) is how fast the owner wants the dog to have eaten the product. Here comes again a contradictory attribute because the dogs perspective cannot be obtained due to lack of verbal skill the only indication is the behaviour map, the speedy engagment with the treat and the oudor.

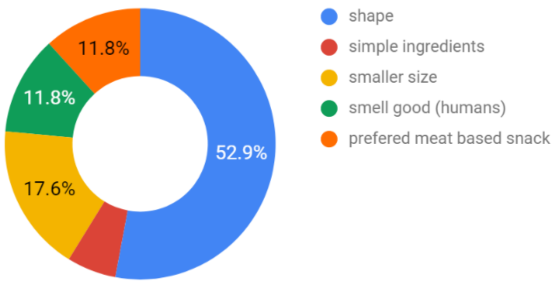


Figure 30: Overall dogs' owner perception for the beer biscuit

Pet industries conduct trials to see whether the dog responds positively or non through monadic or two-bowl testing which show after the consumption over time the weight of the eaten food from the pet. This way the understanding of a pet food is "liked" by the pets (Koppel 2014, Li 2017 and Appendix B).

Also not all dogs are the same and the same applies to humans. As it is observed canine breed plays a role on the size of the treat and texture in general in the palatability of the selection of pet food. As the dog owner 11 said and the dog owner 5 experience a unique situation:

"...there are not many secs between giving the treat and see the reaction because he (N) had instantly swallow it ...for a period of 5 days he ate them, enjoy them...the size is good for a treat and even smaller pieces...shape is less of an issue..." –Dog owner 11

"...the biscuits must have smelled really nice, because she (H) managed to climb up a shelf where they were and got hold of one of the bags and ate them all at once, before I had time to introduce them to her. She had never done that before, and that's where we usually keep the treats... I think the size is better for bigger dogs...I would use them as brain work in the toy-ball and noise working because they obviously smell good...her breed hunts with their eyes and not with their smell...for real training I use meatballs or chicken bites..." - Dog Owner 5

From the above interviews there is a behavioural pattern from the dog being super energetic, curious and generally according to the dog's body language from royal society for the prevention of cruelty to animals (RSPCA) (see Appendix E) 'a happy dog'.

6 Discussion

In this chapter discussion over the outcomes of the findings are explored.

6.1 The upcycled levels of Wet Spent Grain

The incorporation of wet spent grain reached up to 54% in a proposed formulation for dog biscuit whereas current data indicate the incorporation of 15% of dry spent grain in a form of flour for human consumption cookie (Ajanaku, 2011) and up to 50% of wet spent grain for cookie for human consumption (Petrović, 2017).

From the initial stages starting incorporating flour in the wet spent grain gave us the opportunity to witness slowly the progression in the format of the dough. Starting analogies that were tested were 90 wet spent grain and 10 flour moving, 70 % wet spent grain and 30 % flour reaching an analogy of workable dough with wet spent grain and rise flour utilization set at 50-50%.

6.2 Properties of dog biscuit with Brewer's Grain

The new product development process contributed in the research by finding acceptable product prototypes with further aim to final product prototype. The activities during the experimentation with the wet spent grain gave us insights on how the product behaves with flour, egg and oil incorporation. Moreover the comparison of the dog biscuit with commercial snacks on colour and texture provide us with indications that the dog biscuit made from wet spent grain is a material that it can stand close with the commercial dog treats

6.2.1 **Physical**

Slight composition differences in wet spent grain may have an impact in the formulation of the recipe. Between trial 3 and 4 the only change is the composition of the obtained wet spent grain by 4% of wheat flour the rest was 28% of barley. It has to be said that the above brewer's waste composition is among the simplest and most produced. However it is advisable not to focus only in the brewer's composition since the parameters of water activity (a_w) and moisture content are within the range of literature limits. For water activity the produced product has to be below 0.50 in order to eliminate any microorganism that could potentially spoil our product (Nielsen, 2010). Likewise the moisture content needs to be less than 14% (Guy, 2016). Therefore, trials 3 and 4 are within the price range and are corresponding with the range of the commercial treats.

The colorimetry results from studying 5 different formulation showed that the colour difference between the commercial, which act as a control, gave us not the same numeric data for colour difference even though the lowest data appeared in the formulations C, B and E (Appendix M). However, the result studying separately the L*a*b* attributes (table 6 and 9) for commercial and the developed formulations showed that A, B and C having lightness close to the commercials. The recipes A and E by simple observation of the structure they have condense and concrete structure. Observing the colour difference (ΔE) points the trial 3 had all the formulation being below 10 versus the trial 4 above 10 points of ΔE.

From visual illustration of the commercial the porosity and density is acceptable for being present in the treats due to purchasing initiative (see table 8). We observed that formulations (A, D and E) from trials 3 and 4 give us force value close to the commercial ones however from graphical illustration of the breaking force the formulation of A and B are in close range with the commercial ones. There are many reasons that interfere with the result and mainly is the nature of the wet spent grain which is very fibrous and gives 'bumpy' lines in the formulated biscuit and secondly was the not-in-time stabilization of the width of the dough.

6.2.2 **Correlation of different ingredients**

Contribution of whole egg powder can be seen in a visual representation of the formulation E table 8 having more concrete appearance compared with the other formulations that are seem to be more porous. Rapeseed oil contributed to the overall structure and shaping of the dough as well as during handling. Our results for flour selection indicate that all of them are contributing to the formation of the dough indicating that the amount of each of them needs to be further studied regarding the percentages.

6.3 Dog testing with beer brew dog biscuits

It was detected and verified that dogs are influenced by their owners' behaviour towards their eating patterns (Koppel, 2014). The results were that all the dogs tried the dog biscuit even though some of them took more time to be fully eaten.

Regarding the experimental procedure the experience of searching for volunteers are taking a major part of the projects timeline that it needs to be taken into consideration. From dog own interviewers the result was overall positive for the existence of a sustainable product even though the reaction of the dog regarding time duration of eating the biscuits varies.

7 Conclusions and Recommendations

Our goal was to determine the maximum content of wet spent grain that can be incorporated in a recipe for canine consumption in order to sustainably upcycle the brewers by-product and contribute to circular economy. The investigation of how the proposed formulations of the developing dog biscuit with spent grain can be compared with the commercial from a physical perspective. Our results suggest that, reaching the utilisation of 54% wet spent grain has been incorporated in a proposed recipe and the making of the dough has been fulfilled. We showed that formulations of A, B and C are align with the commercial spectrum of colour and the formulations of A, D and E are showing promising breaking forces close to the commercial ones, therefore, there is potential improvement as far as the developmental process in order to further formulate a final product.

When the new product development process is followed the final aim is to formulate a final product prototype and to the launch it in the market for evaluation or further improvements (see figure 32). Also, stage 3 and 4 when implemented give a whole overview of the product development revealing possible implications as well as successful outcomes. It is a multidisciplinary work, for instance, marketing and finance.

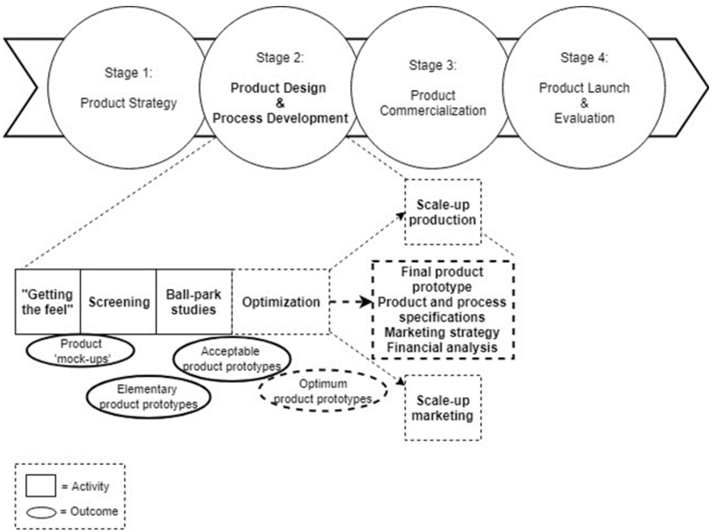


Figure 31: Overview of the sub-stages explored.

7.1 Future research and development suggestions

Further research can be carried out for the creation of business strategy for this product. Continuing a complete new product development process with many more volunteers for more accurate feedback. Also investigation if marketing perspective, marketing trends and appropriate consumer segmentation, price and nutritional recommendations.

In depth product development in investigating how much flour (based on water absorption index) and what kind can be up taken from the wet spent grain. When final product is in place chemical composition is required. Health claims (if any) of the product that is in current market trend is worth investigating. Nevertheless, the narrowing down of formulation can be accomplished with further trials.

Research different materials for 3D printed in order to be more efficient and time effective during baking production

Researching a quick way to accommodate craft breweries transferring their waste from production to a hygienic container for further use in food industry.

References

Adeola, A. A. and Ohizua E. R. (2018) *'Physical, chemical, and sensory properties of biscuits prepared from flour blends of unripe cooking banana, pigeon pea, and sweet potato'*, Food Science and Nutrition, 6(3), pp. 532-540.

American Society for the Prevention of Cruelty to Animals (ASPCA) (2019) *Dog Care: Nutrition Tips*, Available at: https://www.aspca.org/pet-care/dog-care/dog-nutrition-tips (Accessed: 27th April 2019).

Axelsson, E., Ratnakumar, A., Arendt, M.L., Maqbool, K., Webster, M.T., Perloski, M., Liberg, O., Arnemo, J.M., Hedhammar, Å. and Lindblad-Toh, K., 2013. *The genomic signature of dog domestication reveals adaptation to a starch-rich diet.* Nature, 495(7441), p.360.

BAKERpedia (2019) *Water Absorption*, Available at: https://bakerpedia.com/processes/water-absorption/ (Accessed: 28th May 2019).

Bekoff, M & Jamieson, D (2006), *Ethics and the study of carnivores: Doing science while respecting animals. In Animal Passions and Beastly Virtues: Reflections on Redecorating Nature*. Temple University Press, pp. 232-261.

Buggie, F. D. (2001) *'The Four Phases Of Innovation'*, Journal of Business Strategy, 22(5), pp. 36-42.

Case, L. P., Hayek, M. G., Leighann, D., Raasch, M. F., (2011) *Canine and Feline nutrition*, 3rd edn., USA: Mosby Elsevier Inc..

Cepeda-Vázquez, M., Rega, B., Descharles, N. and Camel, V., 2018. *How ingredients influence furan and aroma generation in sponge cake.* Food chemistry, *245*, pp.1025-1033.

Chen, P., Liu, X., Zhang, X., Sangwan, P. and Yu, L., 2015. *Phase transition of waxy and normal wheat starch granules during gelatinization*. International Journal of Polymer Science, 2015.

Chieh, P. C. (2014) *'Water'*, in Zhou W and Hui, Y.H (ed.) *Bakery Products Science and Technology* . UK: John Wiley & Sons, Ltd, pp. 129-152.

Earle, M. and Earle, R. (2000) *Creating New Foods. The Product Developer's Guide.* The New Zealand Institute of Food Science & Technology (NZIFST) [Online].

Available at: https://nzifst.org.nz/resources/creatingnewfoods/index.htm (Accessed: 26th April 2019).

Edgett, S.J. (2019) *The Stage-Gate Model: An Overview*, USA: Stage-Gate International.

Environmental Protection Agency in UN (EPA) (2019) *Food Recovery Hierarchy*, Available at: https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy (Accessed: 28th May 2019)

Eurostat (2018) *Agricultural production - crops*, Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_production_-_crops#Cereals (Accessed: 20th April 2019).

European Commission Directive (1982) "*laying down the categories of ingredients which may be used for the purposes of labelling compound feeding stuffs for pet animals (82/475/EEC)'*, Official Journal of the European Communities, L 213/27

European Pet Food Industry Federation (FEDIAF), *Dog population in the EU 2017, by country* | Statistics. *Statista*. Available at: https://www.statista.com/statistics/414956/dog-population-european-union-eu-by-country/ [Accessed April 29, 2019].

Foreign Agricultural Service- United Stated Department of Agriculture (FAS-USDA) (2019) *World Agricultural Production*, USA: Circular Series.

Galanakis, C.M. ed., (2016). *Innovation strategies in the food industry: tools for implementation*. Academic Press.

Galanakis, C.M. ed., (2018). *Sustainable recovery and reutilization of cereal processing by-products*. Woodhead Publishing.

Grunde, J., Li, S. and Merl, R., 2014. *Craft Breweries and Sustainability: Challenges, Solutions, and Positive Impacts*.

Guy, R. C. E. (2004) *'PET Foods'*, in Wrigley, C. (ed.) Encyclopedia of Grain Science. Australia: Elsevier Ltd., pp. 445-450.

Haegens, N., 2006. *Mixing, dough making, and dough makeup*. Bakery Products: Science and Technology, pp.245-248.

Heuzé V., Tran G., Sauvant D., Lebas F., (2017) *Brewers grains*, Available at: https://www.feedipedia.org/node/74 (Accessed: 26th January 2019).

Hooijdonk, R. (2019). *The future of food: up-cycling food waste and the blue economy*, Available at: https://www.richardvanhooijdonk.com/en/blog/future-food-upcycling-food-waste-blue-economy/ (Accessed: 28th May 2019).

Ikram, S., Huang, L. Y., Zhang, H., Wang, J., and Yin, M. (2017) *'Composition and Nutrient Value Proposition of Brewers Spent Grain'*, Journal of Food Science, 82(10), pp. 2232-2242.

Inal, F., Alataş, M. S., Kahraman, O., İnal, Ş., Uludağ, M., Gürbüz, E., & Polat, E. S. (2017). Barley as an alternative to rice in dog food. *Turkish Journal of Veterinary and Animal Sciences*, *41*(6), 770-774.

Jordbruks verket (2009), *Facts about Swedish Agriculture*, Sweden.

Kiosseoglou, V. and Paraskevopoulou, A., 2014. *Eggs*. *Bakery products science and technology*, pp.243-258.

Kopsachilis A., (2005), '*Alcoholic fermentation in the production of beer – new trends'*, B.Sc. thesis, Technological Educational Institute of Peloponnese, Greece.

Korivaara S., Passport (2019) *Beer in Eastern Europe*, Ireland: Euromonitor International.

Koerten, J., Passport (2019) *Innovation in Pet Food: Premiumisation and segmentation*, Ireland: Euromonitor International

Koppel, K. (2014) *'Sensory analysis of pet foods'*, in Shepherd, M. and Waterhouse, A. (ed.) Journal of the Science of Food and Agriculture . Online: Wiley Online Library, pp. 2148-2153.

Kocher, N. (2018) *Cost Benefit Analysis of Food Waste Processing in Massachusetts* (Doctoral dissertation).

Ktenioudaki, A., Chaurin, V., Reis, S.F. and Gallagher, E., 2012. *Brewer's spent grain as a functional ingredient for breadsticks*. International journal of food science & technology, 47(8), pp.1765-1771.

Lakna, P. (2017) *Difference between lipids and fats*, Available at: https://www.researchgate.net/publication/320707103_Difference_Between_Lipids_and_Fats (Accessed: 29th May 2019).

Li, H., Smith, S., Aldrich, G. and Koppel, K., (2018). *Preference ranking procedure proposal for dogs: A preliminary study*. Journal of Sensory Studies, 33(1), p.e12307.

Lynch, K.M., Steffen, E.J. and Arendt, E.K., (2016). *Brewers' spent grain: a review with an emphasis on food and health*. Journal of the Institute of Brewing, 122(4), pp.553-568.

Marangoni, A., Goldstein, A. and Seetharaman, K., 2014. Lipids: Properties and Functionality. *Bakery Products Science and Technology*, pp.223-241.

Manley, D. ed., (2011). *Biscuit baking* in Manley's technology of biscuits, crackers and cookies. Elsevier, pp. 478-500

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., Morgan, C. A., Sinclair, L. A., Wilkinson, R. G. (2011) *Animal nutrition , 7th edn*., GB: Pearson Education Limited

Messonnier, S. (2012*) Nutritional Supplements for the Veterinary Practice - A pocket guide*, USA: American Animal Hospital Association Press.

Misra, N.N and Tiwari, B. K. (2014) '*Biscuits'*, in Zhou, W. and Hui, Y. H. (ed.) Bakery Products Science and Technology . UK: John Wiley & Sons, Ltd, pp. 585-602.

Mosher, M., Trantham, K. (2017) *Brewing Science: A Multidisciplinary Approach*, eBook edn. Switzerland: Springer International Publishing AG

Mussatto, S.I., Dragone, G. and Roberto, I.C., 2006. *Brewers' spent grain: generation, characteristics and potential applications*. Journal of cereal science, 43(1), pp.1-14.

National Veterinary Institute (SVA) (2018) *Dogs*, Available at: https://www.sva.se/en/animal-health/dogs (Accessed: 29th April 2019).

New food (2009) *Future applications for brewers' spent grain,* Available at: https://www.newfoodmagazine.com/article/269/future-applications-for-brewers-spent-grain/ (Accessed: 28th April 2019).

Online Etymology Dictionary (2019) *Rice* (c.), Available at: https://www.etymonline.com/word/rice (Accessed: 29th May 2019).

Passport (2018) *Beer in Sweden*, Ireland: Euromonitor International.

Passport (2018) *Dog food in Sweden*, Ireland: Euromonitor International.

Passport (2018) *Dog and cat food packaging in Sweden*, Ireland: Euromonitor International

Petrović, J., Rakić, D., Fišteš, A., Pajin, B., Lončarević, I., Tomović, V. and Zarić, D., 2017. *Defatted wheat germ application: Influence on cookies' properties with regard to its particle size and dough moisture content*. Food Science and Technology International, 23(7), pp.597-607.

Purlis, E., 2014. *Browning in Bakery Products: An Engineering Perspective*. Bakery Products Science and Technology, pp.417-430.

Puri, S., Dhillon, B. and Sodhi, N.S., 2015. *A study on the effect of degree of milling (DOM) on colour and physicochemical properties of different rice cultivars grown in Punjab.* International Journal of Advanced Biotechnology and Research (IJBR), 6(3), pp.310-319.

Rossel, C. M. and Gomez, M. (2014) 'Rice', in Zhou, W. and Hui, Y. H. (ed.) *Bakery Products Science and Technology.* UK: John Wiley & Sons, Ltd, pp. 89-106.

Rodriguez-Sandoval, E., Sandoval, G. and Cortes-Rodríguez, M., (2012). *Effect of quinoa and potato flours on the thermomechanical and bread making properties of wheat flour.* Brazilian Journal of Chemical Engineering, 29(3), pp.503-510.

Rudder, A., Ainsworth, P. and Holgate, D. (2001) *'new food product development: strategies for success?'* British Food Journal, 103(9), pp. 657-671.

Sjöö, M. and Nilsson, L. (2018) *Starch in Food: Structure, Function and Applications*, 2nd edn., UK: Woodhead Publishing.

Skendi, A., Harasym, J., Galanakis, C. M. (2018*) 'Recovery of high added-value compounds from brewing and distillate processing by-products'*, in Galanakis, C. M. (ed.) Sustainable Recovery and Reutilization of Cereal Processing By-Products. UK: Elsevier, pp. 189-214.

Stier, J. (2010*) Solid Waste Reduction Manual*, USA: Brewers Association

Thiranusornkij, L., Thamnarathip, P., Chandrachai, A., Kuakpetoon, D. and Adisakwattana, S. (2018) *'Physicochemical Properties of Hom Nil (Oryza sativa) Rice Flour as Gluten Free Ingredient in Bread'*, Foods, 7(10), pp. 1-13.

The Brewers of Europe (2018) *Beer statistics*, Available at: https://brewersofeurope.org/uploads/mycms-files/documents/publications/2018/EU-beer-statistics-2018-web.pdf (Accessed: 28th May 2019).

United Nation Sustainable Goals UNSG (2019) *Goal Nº12: Ensure sustainable consumption and production patterns*, Available at: https://www.un.org/sustainabledevelopment/sustainable-consumption-production/ (Accessed: 28th May 2019).

Unger, N. and Razza, F., 2018. *Food Waste Management (Sector) in a Circular Economy.* In Designing Sustainable Technologies, Products and Policies (pp. 127-132). Springer, Cham.

United States Department of Agriculture (USDA) (2019) *Grain: World Markets and Trade*, Available at: https://www.fas.usda.gov/data/grain-world-markets-and-trade (Accessed: 28th May 2019).

Waterschoot, J., Gomand, S.V., Fierens, E. and Delcour, J.A., 2015. *Production, structure, physicochemical and functional properties of maize, cassava, wheat, potato and rice starches.* Starch-Stärke, *67*(1-2), pp.14-29.

Wall, T. (2019) *Pet owners most want plant-based diet nutrition info*, Available at: https://www.petfoodindustry.com/ (Accessed: 26th April 2019).

Wani, A.A., Singh, P., Shah, M.A., Schweiggert-Weisz, U., Gul, K. and Wani, I.A. (2012) *'Rice Starch Diversity: Effects on Structural, Morphological, Thermal, and*

Physicochemical Properties—A Review', Comprehensive Reviews in Food Science and Food Safety, 11(5), pp. 417-436.

Ward, A., Passport (2017) *Ethical Living case study in beer: an opportunity too good to waste?*, Ireland: Euromonitor International

Yadav, R.B., Kumar, N. and Yadav, B.S., 2016. *Characterization of banana, potato, and rice starch blends for their physicochemical and pasting properties*. Cogent Food & Agriculture, *2*(1), p.1127873.

Zhou, W. (2014) *Bakery Products Science and Technology*, 2nd edn., UK: John Wiley & Sons, Ltd.

Appendix A Benchmarking

	Brand	Products' Name	Ingredients	Analytical constituents
1	Earthborn Holistic	Earthbites skin &Coat	Whitefish Meal, Peas, Pea Starch, Honey, Tapioca, Glycerine, Salmon Meal, Dried Egg Product, Pea Fibre, Canola Oil (preserved with Mixed Tocopherols, Natural Flavours, Phosphoric Acid, Apples, Blueberries, Carrots, Spinach, Cranberries, Flaxseed, Salt, Potassium Sorbate (preservative), Vitamin E Supplement, Mixed Tocopherols (preservative), Rosemary Extract, Green Tea Extract, L-Ascorbyl-2-Polyphosphate (source of Vitamin C), Dried Lactobacillus Acidophilus Fermentation Product, Dried Enterococcus Faecium Fermentation Product, Dried Lactobacillus Casein Fermentation Product.	Crude Protein minimum 16.00%, Crude Fat minimum 6.00%, Crude Fibre maximum 4.00%, Moisture. maximum 24.00%, Vitamin E minimum 200 IU/kg, Ascorbic Acid (Vitamin C) minimum 100 mg/kg*,Omega-6 Fatty Acids minimum 1.00%*, Omega-3 Fatty Acids minimum 1.00%* Calorie Content: (M.E. Calculated as fed) 2845 kcal/kg 5 kcal/treat.
2	Natural balance	Sweet Potato & Venison formula treats	Dried Potatoes, Sweet Potatoes, Potato Protein, Cane Molasses, Venison, Canola	Crude Protein 18.0% minimum Crude Fat 6.0% minimum Crude Fibre 3.0% maximum Moisture 10.0% maximum.

			Oil, Sodium Chloride, Natural Hickory Smoke Flavour, Calcium Carbonate, Natural Mixed Tocopherols, Citric Acid, Rosemary Extract.	
3	Purina - adventurous nuggets	pig wild flavour, low in fat, no added artificial colorants	cereals, glycerol, meat and animal derivatives(8%), various sugars, vegetable protein extract,	
4	pedigree	Tasty nites crunchy pockets with chicken	Cereals, Oils and Fats, Meat and Animal Derivatives (including 4% Chicken),Minerals, Derivatives of Vegetable Origin, Vegetable Protein Extracts	Protein29.1 % Fat content25.5 Inorganic matter9.6 Crude fibres0.7 Energy449 kcal/100g Calcium1.7 Omega 3 fatty acids0.6 Antioxidants Nutritional additives Vitamin A18333 U Vitamin D32022 IU Vitamin E249 mg Cupric sulphate pentahydrate41.2 mg Ferrous sulphate monohydrate45.2 mg Manganous sulphate monohydrate58.1 mg 3.4 mg 3.4 mg Zinc sulphate monohydrate259 mg
5	pedigree	biscrok original	Cereals, meats and derivatives (including 4% chicken in white biscuits, including 4% beef in brown biscuits, 4% lamb in red cookies), vegetable by-products, oils and fats, mineral substances, seeds, aromatic plants .	Raw protein 13.5% Raw fats 8% Raw ash 6% Raw fibre 2% Football 1.2% Omega 3 fatty acids 605 mg / kg Energy value 359 Kcal / 100 gr
6	IMK9		oat flour, peanut butter, blueberries, chia seed, vitamin e	Crude protein crude fat crude fibre moisture DHA omega 3 omega 6 kcal/kg
7	vitacraft	boony bits	meat and animal derivatives 51.1%, cereals, derivatives of vegetable origin, yeast, supplemented additives(3a672a, vitA(I.E.), E671 Vit D3(I.E.), Vit E(mg)) contains antioxidant, preservatives and colourings	moisture %, protein, fat content, crude fibres, crude ash
8	AB Dogman, Astorp		cereals, meat and animal derivatives, oil and fat derivatives of	crude protein, crude oil and fat, crude ash, calcium phosphor, vitamins A, D3, E., trace elements Iodine E2, Mangan E5, Copper E4, Iron E1, Zink E6, EEC approved

			vegetable origin minerals and fish derivatives	preservatives, antioxidants, colorants, flavouring
9	Best friend Finland (labelling) (manufacturing) Denmark by best friend	original natural bites	Dried chicken 100%.	40.2% protein, 12.0% fat content, 3.8% annealing residue, fibre content <0.6%, moisture 20.4%.
10	Dogman	klassiskt faviritgodis for hund	Cereals, meat and animal derivatives, oils and fat, derivatives of vegetable origin, minerals, fish and fish derivatives	crude protein(25%), oil and fat(7.5%), fibres(2.5), ash(7), calcium(1.7), phosphor(1.1)
11	Eldorado	Kaustange supplementary food for dogs	cereals, meat, animal by-products, oil, fat, minerals	Crude protein 22%, crude ash 7%, crude fat, 5%, crude fibre 3%
12	Eldorado	Puppy treats supplementary food for dogs	cereals, meat by-products, animal by-products, oil, fat, minerals	Crude protein 6.6%, crude ash 1.4%, crude fat, 7.3%, crude fibre 0.2%
13	Specific	Healthy Treats for all breeds and ages	Cereals, fish and fish derivatives, derivatives of vegetable origin, vegetable protein extracts, meat and animal derivatives, minerals, eggs and egg derivatives, oils and fat	Protein 22%, fat content 4%, crude fibres 4.8%, crude ash 5.6% calcium 0.94%, phosphorous 0.62% omega-3 fatty acids 0.32% nutritional additives, binders and antioxidants
14	Telford PA	brewbiscuits	Spent Beer Grain (barley, oats, rye), Flour, Eggs and Flavour: Peanut Butter, Pumpkin or Sweet Potato	
13	New Zealand (Garage project)	Mashbone	spent mash by-product and NZ grass-fed beef	
14	(USA, Texas) Hops & Grain Brewing	Bizarre Bites // Brew Biscuits	whole wheat flour, cinnamon, eggs and few other tasty all-natural ingredients and bake away	
15	Conklin, NY	Hungry Hund - Beer Grain Treats	Fresh brewers' grain and fresh local eggs.	
16	Kansas City, Missouri	Beer Paws Spent Grain Dog Treats	brewers grain's, flour, egg, and peanut butter	

Appendix B Contacted Sources

	Contacted person	Studies	Location	Position in workplace
	1	Veterinary	USA	Online “ask-a-vet”
	2	Veterinary	USA	Online “askavetquestion”
	3	Chemical engineer	Lund, Sweden	Brewery Engineer
	4	Business	Lund, Sweden	Brewery CEO
	5	Pet trainer	Lund, Sweden	Pet store owner
	6	-	Lund, Sweden	Store seller
	7	Veterinary	Lund, Sweden	Lund university
	8	Food engineer	North USA	R&D in Pet industry
	9	Food engineer	Netherlands	R&D in Pet industry
	10	Animal Science	Sweden	R&D in Pet industry

Appendix C Interview from dog owners and their dogs

Dog Owners	**Dogs**	**Breed**	**Age**	**Diet**	**Usual snacks/treats**
1	A	Poodle	9 months	dry	liver snacks
	B	Poodle	13	dry	liver snacks
	C	mini Poodle	11 months	dry	liver snacks
2	D (1)	Mix border collie (50%)-Nova Scotia Duck Tolling Retriever (50%)	7 1/2	dry with dinner leftovers	cheese, meat, sausages

	E	mix Border collie (25%)-Nova Scotia Duck Tolling Retriever (75%)	3 1/2	dry with dinner leftovers	cheese, meat, sausages
3	F	mix irish terrier	10 1/2	dry	candy snack
4	G	mix setter retriever	2	raw - vet	normal meaty flavour
5	H	mix lagotto poodle	4 1/2	dry	rarely chicken
6	I	scottish terrier	8	dry and human food	meat flavour
7	J	italian greyhound	1 1/2	vet wet food, barf, sensitivities not up to now	dry chicken
8	K	miniature schnauzer	2	dry pet food	normal meaty flavour
9	L	shih tzu jack russell mix	1	fresh frozen food	dehydrated meet
10	M	mix of 3 breeds	7	dry and human food	meat based
11	N	Golden retriever	1 1/2	dry	dry liver, sausages, crackers
12	O	Mix terrier	15	(to be answered)	(to be answered)

Appendix D Food NPD processes

According to Ainsworth 2001, Graf and Saguy (1991) having experience in food industry issued a 5-step food oriented NPD process and proceed in subdivide those steps in sections. In this way they manage the steps more effectively. The proposed 5-step were: screening of ideas, feasibility, development, commercialization and maintenance.

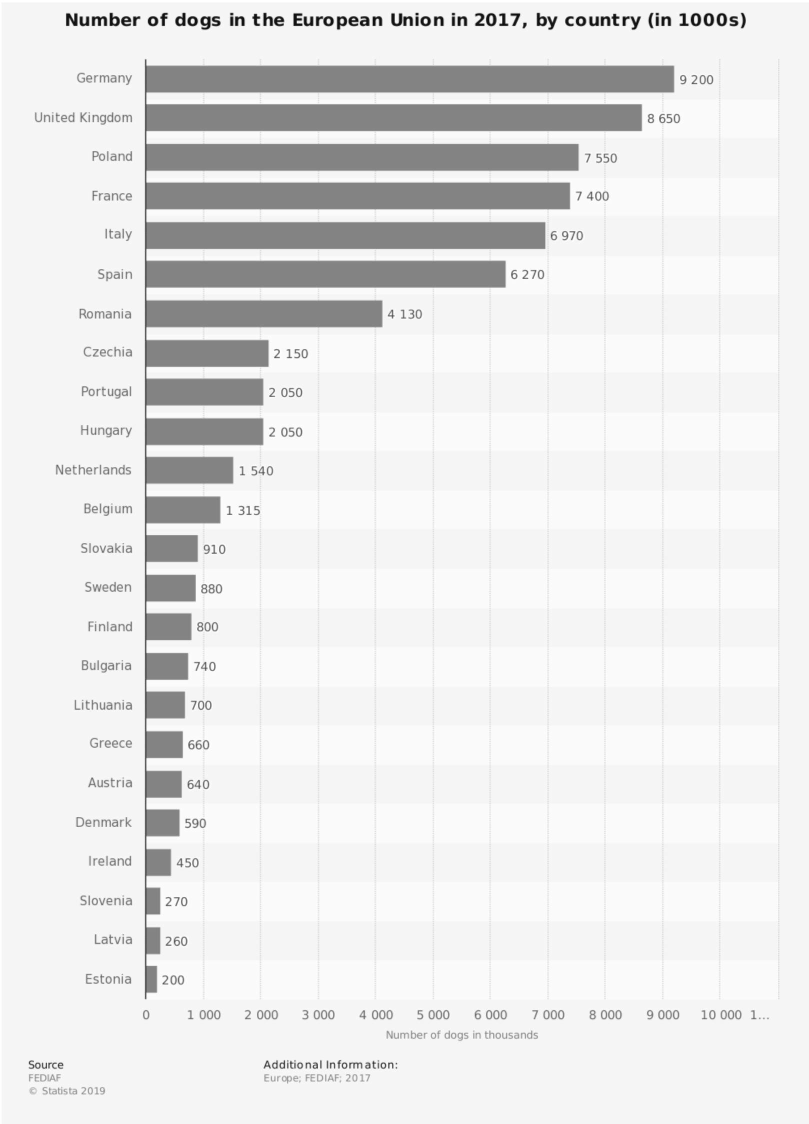
1. Screening of ideas. This step starts with identifying ideas for products by brainstorming. A “list of concrete products and quality attributes” was formed and the selected product was going through a “cursory analysis” were the product is assessed for quality, self-life stability and packaging. Then a consumer trial will take place in order to further assess.
2. Feasibility steps includes technological, manufacturing and financial aspects.
3. Development is very crucial step. It occupies large part of the NPD process from several weeks to many years. The recipe needs to be scaled up into a formula for the manufacture industry. Packaging requirements are also discussed in this step.
4. Commercialization step is the viability of the product in the market
5. Maintenance step is making adjustments to the product if necessary.(Ainsworth, 2001)

Fuller (1994) strongly recommend that the NPD process needs to have 6-phases. Those phases need to be in harmony and can co-exist, when one phase has not finished the next one can begin. It can overlap and it is a process that constantly evolves. The proposed 6-phases are: idea screening, screening of ideas, development, production, consumer trials, and test-market.

1. Idea screening, through idea generation include the company’s objectives and consumer’s needs.
2. Screening of ideas is the cover of the financial review and feasibility.
3. Development is the creation of a tangible product following up with sensory and acceptance qualities with the aim to place the product in the market with the least amount of uncertainty.
4. Production phase is a set of product specifications for a safe product.
5. Consumer trials are helping in acceptance and correlation of sensory attributes with the product. Trained panellists are used for sensory analysis. Small groups are 4-5 people, focus groups are 8-12 people and “in-house” testing are with several hundred.
6. Test market phase is an ongoing screening process where data is analysed and product re-evaluated. (Ainsworth, 2001)

Appendix E Dogs’ body language (RSPCA)

Appendix F Dogs in EU 2017



Appendix G Common Canine Food ingredients

BOX 16-4 COMMON PET FOOD INGREDIENTS

Primary nutrient contribution			
Protein	**Carbohydrate**	**Fat**	**Dietary Fiber**
Beef	Alfalfa meal	Animal fat	Apple pomace
Brewer's dried yeast	Barley	Chicken fat	Barley
Chicken meal	Brewer's rice	Corn oil	Beet pulp
Chicken liver meal	Brown rice	Fish oil	Cellulose
Chicken byproduct meal	Carrots	Flax seed (full fat)	Citrus pulp
Chicken	Dried kelp	Poultry fat	Oat bran
Chicken byproducts	Dried whey	Safflower oil	Peanut hulls
Corn gluten meal	Flax seed	Soybean oil	Pearled barley
Dried egg product	Flax seed meal	Sunflower oil	Peas
Duck	Grain sorghum	Vegetable oil	Rice bran
Fish	Ground corn		Soybean hulls
Fish meal	Ground rice		Soybean mill run
Flax seed meal	Ground wheat		Tomato pomace
Lamb	Molasses		
Lamb meal	Oat meal		
Meat byproducts	Pearled barley		
Meat meal	Peas		
Meat and bone meal	Potatoes		
Poultry byproduct meal	Rice flour		
Rabbit	Wheat (ground)		
Salmon	Wheat flour		
Soy flour or grits			
Soybean meal			
Turkey			

Appendix H Consent form of dog owner

Owner informed consent form

To be filled out by the pet owner,

Owner Name	
Contact information (email, phone)	
Date received pet snack	
Date interviewed	

Project by: Kyriaki Chanioti

Project outline

The project is part of a master thesis in Lund University. The dog owner is participating voluntarily with their dog in this project. The snack is suitable for dogs, all ages and all breeds. Participants can withdraw at any time. Please read the ingredient list carefully and make sure that your dog is able to consume the tested product.

List of Ingredients:

Barley cereal, whole egg, rice flour, potato flour, **wheat flour**, corn flour, rapeseed oil

Statement:

a) As the owner of this animal, I confirm that I have read and understand the above information. ☐
b) I am agreeing to participate in this project voluntarily and I am free to withdraw at any time. ☐

c) I clearly state that my dog is **NOT allergic** to any of the ingredients above. ☐

As a pet owner I have read the above information given to me and I give my consent to take part in the project.

______________________________ ____________

Owner signature and name Date

Appendix I Dog Biscuit Testing Instructions

Biscuit Instructions for You and your Dog

First of all THANK You for your participation! ☺

General rules **!**

The developing biscuit is mend to be consumed by your dog as a snack and NOT as a daily pet food.

You can skip giving to your dog the snack according to the dog's behavior. We want the dog to enjoy the snack.

Instructions

- For You (dog owner)

If it is possible, **record** in a video the dog's consumption of the snack. If not try to see if you recognize any difference in its behavior when you give them the biscuit.

Within a week (5days) you may give to your dog 1 max 2 pieces of biscuits in a Day.

Steps:

1) Record your dog when you give your own snacks (commercial)
2) Place in your palm A and B biscuit and approach your dog's mouth. (see pic.)

a. This step could be in a different time of the day. Not necessarily at the same time as the step 1.

3) Remember to record the action. See which one does eats first (general it's behavior)

4) In the given questionnaire write any particular action that you recognized in your dog when consuming the biscuit

Final notes:

The videos are for purpose of the thesis and only. They will assist in evaluating and interpretation of the results.

Remember! This is a fun process for you and your dog. Enjoy & see you in a week!! ☺

If you have any question do not hesitate to contact me at: Ky8711ch-s@student.lu.se , 0737550596

Appendix J Interview format

Questions during Interview

Dog breed:

Dog age:

Dog diet:

Dog weight:

a) Very thin
b) Underweight

c) Ideal
d) Overweight
e) Obese

How often do you purchase snacks/treats for your dog?

a) Once a week
b) Once a month
c) Once every 2 months
d) Other:____

When do you give your dog's treat? In which occasion?

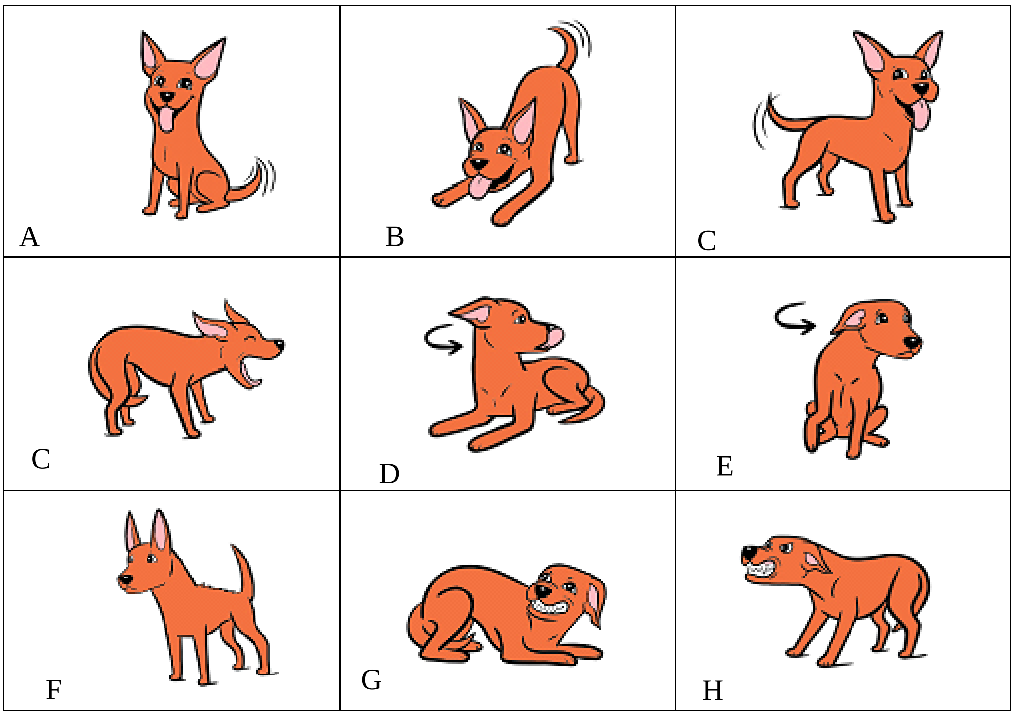
a) As a reward
b) Because I feel like it
c) Other:____

What do you look when buying a dog treat? (more than one)

a) Price
b) Health benefits
c) Packaging
d) Sustainable ingredients been used
e) Vegetarian ingredients
f) Veterinarian recommendation
g) How is been advertised
h) Self-life
i) Other:____

What was the behavioral characteristics of your dog (pictures, owner perspective)

1) Before eating (did is smell it?, ignore it, curious)
2) During eating (had any trouble of shewing, swallowing)
3) After eating (wanting more?)



(RSPCA, 2019)

The snack was given at:

a) Home
b) Outdoors
c) Other:_____

How did you gave the treat to your dog? (Describe)

Would you buy for your dog a sustainable and healthy dog snack?

a) Yes
b) No

What is your overall perception of this product?

Appendix K Poster

Appendix L 82/475/EEC

	Description of the category	Definition
1.	Meat and animal derivatives	All the fleshy parts of slaughtered warm-blooded land animals, fresh or preserved by appropriate treatment, and All products and derivatives of the processing of the carcase or parts of the carcase of warm-blooded land animals
2.	Milk and milk derivatives	All milk products, fresh or preserved by appropriate treatment, and derivatives from the processing thereof
3.	Eggs and egg derivatives	All egg products fresh or preserved by appropriate treatment and derivatives from the processing thereof
4.	Oil and fats	All animal and vegetable oils and fats
5.	Yeasts	All yeasts, the cells of which have been killed and dried
6.	Fish and fish derivatives	Fish or parts of fish, fresh or preserved by appropriate treatment, and derivatives from the processing thereof
7.	Cereals	All types of cereal, regardless of their presentation, or products made from the starchy endosperm
8.	Vegetables	All types of vegetables and legumes, fresh or preserved by appropriate treatment
9.	Derivatives of vegetables	Derivatives resulting from the treatment of vegetable products, in particular cereals, vegetables, legumes and oil seeds
10.	Vegetable protein extract	All products of vegetable origin in which the proteins have been concentrated by an adequate process to contain at least 50% crude protein, as related to the dry matter, and which may be restructured (textured)
11.	Minerals	All inorganic substances suitable for animal feed

12. Various sugars	All types of sugar
13. Fruit	All types of fruit, fresh or preserved by appropriate treatment
14. Nuts	All kernels from shells
15. Seeds	All types of seeds as such or roughly crushed
16. Algae	Algae, fresh or preserved by appropriate treatment
17. Molluscs and crustaceans	All types of molluscs, crustaceans, shellfish, fresh or preserved by appropriate treatment, and their processing derivatives
18. Insects	All types of insects and their stages of development
19. Bakery products	All bread, cakes, biscuits and pasta products

Appendix M ΔE colour differences commercial and tried recipes

M.1 Trial 3

	L*	a*	b*	ΔE	Notes
Eldorado-Kaustange	58,9±0,6	7,84±0,3	24,35±0,9	0	control
A	21,87±6,9	7,68±1,2	26,11±3,5	37,072	
B	57,13±15,3	5,56±0,9	18,91±0,9	6,158	
C	62,61±4,3	3,97±3,5	19,55±3,7	7,196	
D	61,52±9,5	4,91±3,1	21,68±1,6	4,752	Closer to control
E	37,49±14,2	8,8±0,9	22,55±5	21,507	

	L*	a*	b*	ΔE	Notes

Eldorado-Puppy treat	56,97±2,2	8,31±0,4	24,69±0,8	0	control
A	21,87±6,9	7,68±1,2	26,11±3,5	35,134	
B	57,13±15,3	5,56±0,9	18,91±0,9	6,403	Closer to control
C	62,61±4,3	3,97±3,5	19,55±3,7	8,779	
D	61,52±9,5	4,91±3,1	21,68±1,6	6,428	
E	37,49±14,2	8,8±0,9	22,55±5	19,603	

	L*	a*	b*	ΔE	Notes
Dogman-Klassiskt	43,37±1,6	7,14±0,4	18,43±1,1	0	control
A	21,87±6,9	7,68±1,2	26,11±3,5	22,837	
B	57,13±15,3	5,56±0,9	18,91±0,9	13,859	
C	62,61±4,3	3,97±3,5	19,55±3,7	19,532	
D	61,52±9,5	4,91±3,1	21,68±1,6	18,573	
E	37,49±14,2	8,8±0,9	22,55±5	7,369	Closer to control

	L*	a*	b*	ΔE	Notes
Specific-Healthy Treats	43,42±5,3	7,28±0,9	23,73±1,7	0	control
A	21,87±6,9	7,68±1,2	26,11±3,5	21,684	
B	57,13±15,3	5,56±0,9	18,91±0,9	14,634	
C	62,61±4,3	3,97±3,5	19,55±3,7	19,917	
D	61,52±9,5	4,91±3,1	21,68±1,6	18,369	
E	37,49±14,2	8,8±0,9	22,55±5	6,234	Closer to control

M.2 Trial 4

	L*	a*	b*	ΔE	Notes
Eldorado-Kaustange	58,9±0,6	7,84±0,3	24,35±0,9	0	control
A	20.77± 5,8	7.30±1,4	26.70±4,5	38,206	
B	31.55±13,8	5.68±0,8	21.02±1,0	27,636	
C	32.12±17,9	7.53±2,2	27.61±4,1	26,979	'Closer' to control
D	26.14±8,4	6.26±1,0	23.27±2,7	32,816	
E	31.19±15,3	9.37±1,7	28.99±6,0	28,137	

	L*	a*	b*	ΔE	Notes
Eldorado-Puppy treat	56,97±2,2	8,31±0,4	24,69±0,8	0	control
A	20.77± 5,8	7.30±1,4	26.70±4,5	36,269	
B	31.55±13,8	5.68±0,8	21.02±1,0	25,817	
C	32.12±17,9	7.53±2,2	27.61±4,1	25,033	'Closer' to control
D	26.14±8,4	6.26±1,0	23.27±2,7	30,931	
E	31.19±15,3	9.37±1,7	28.99±6,0	26,158	

	L*	a*	b*	ΔE	Notes
Dogman-Klassiskt	43,37±1,6	7,14±0,4	18,43±1,1	0	control
A	20.77± 5,8	7.30±1,4	26.70±4,5	24,066	
B	31.55±13,8	5.68±0,8	21.02±1,0	12,188	Closer to control
C	32.12±17,9	7.53±2,2	27.61±4,1	14,525	
D	26.14±8,4	6.26±1,0	23.27±2,7	17,918	

E	31.19±15,3	9.37±1,7	28.99±6,0	16,274	

	L*	a*	b*	ΔE	Notes
Specific-Healthy Treats	43,42±5,3	7,28±0,9	23,73±1,7	0	control
A	20.77± 5,8	7.30±1,4	26.70±4,5	22,844	
B	31.55±13,8	5.68±0,8	21.02±1,0	12,281	
C	32.12±17,9	7.53±2,2	27.61±4,1	11,950	Closer to control
D	26.14±8,4	6.26±1,0	23.27±2,7	17,316	
E	31.19±15,3	9.37±1,7	28.99±6,0	13,476	