Development of Protein Fortified Puddings with Acceptable Sensory Properties for Older Adults
by
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ABSTRACT

DEVELOPMENT OF PROTEIN FORTIFIED PUDDINGS
WITH ACCEPTABLE SENSORY PROPERTIES FOR OLDER ADULTS

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Malnutrition is a serious problem among the older population; often it is associated with protein deficiency. Fortifying food with protein could help reduce the risk of malnutrition. Eight chocolate puddings fortified with soy and whey protein were developed using an experimental design. The nutritional and sensory properties of the puddings were evaluated. Different sensory methods were used including descriptive analysis (age 18-32, n=12), napping (age 18-35, n=15) and liking acceptance combined with check-all-that-apply (age 60+, n=61). Protein addition changed protein content and sensory properties of the food. The increase in protein decreased the liking scores. Differences in the way the older adults described and rated the puddings were also identified. The outcomes obtained from this study provided significant information about the sensory properties of the chocolate puddings. In order to develop puddings that will be well accepted by older adults, the amount of protein could not be higher than 6%.
Acknowledgements

First, I have to thank God, who is the one that made this dream come true, without Him nothing would be possible. Thank you also to all my family, specially my husband Corey for all the support and love along this journey. Words cannot describe how much I love and appreciate all he has done for me.

For my advisor Dr. Lisa Duizer, I would like thank for all her guidance, patient and knowledge extended to me. I could not have done without all your help and understanding.

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CHAPTER 1- INTRODUCTION

Worldwide, the population is aging, and life expectancy is increasing. In Canada, older adults constitute the fastest growing segment of the population. Older adults are defined as individuals aged 65 years or more (Health Canada, 2011). It is estimated that the number of older adults will double from 5 million, where it is today, to 10.4 million by 2036 (nearly one in four Canadians). In addition, the life expectancy for men and women in Canada is believed to reach 81 and 86 years, respectively by 2031 (Federation of Canada Municipalities, 2013; Statistic Canada, 2008). As people get older, they are likely to develop health problems that cause them to increase their use of health services, and given the increasing numbers of older adults, health care expenditures for the government will increase (Canada Institute for Health Information, 2014).

One of the major health problems observed in the older adult population is malnutrition. It is a particularly prevalent problem for individuals living in Long Term Care Homes (LTC). Residents of LTC often present signs of depression, cognitive and functional deficiencies, swallowing difficulties and energy-protein deficiency, and these factors are responsible for the increase prevalence of malnutrition (Bell, Lee & Tamura, 2015). Elia in Stratton et al. (2003) defines malnutrition as “a state of nutrition in which a deficiency of energy, protein and other nutrients cause adverse effects on tissue or body form (body shape, size and composition), function or clinical outcomes.” Malnutrition negatively impacts older adults by decreasing their functional status, psychological well-being and quality of life (Chen et al., 2001; Dey et al., 2001). Therefore, prolonging hospital care and increasing costs with hospitalization (Amaral et al., 2007). Functional status is an indicator of someone’s ability to complete daily activities,
such as walking, bathing, eating and cooking, without assistance. It is a measure of their independence, which is important to both their health and quality of life (CRNCC 2006; Lum et al. 2010).

As shown by the previous definition, inadequate protein consumption is a form of malnutrition, and there is a high prevalence of protein deficiency among older adults (Ter Borg, 2015). The Recommended Dietary Allowance (RDA) for protein for adults is 0.8 g/kg body mass/day, regardless of age (European Food Safety Authority, 2012; Institute of Medicine, 2005). This recommendation is the minimum requirement to avoid negative nitrogen balance. A negative nitrogen balance is responsible for reducing lean body mass, which is a detriment to an older adult. Many studies have shown that consumption of an amount of protein, higher than the recommended by RDA, would bring additional health benefits for older adults (Rousset, et al., 2003; Boersheim et al., 2008; Beasley et al., 2010), such as preventing loss of muscle mass and increasing strength. This will reduce the incidence of frailty, disability and will improve autonomy (Phillips et al., 2016). There is not a consensus on how much protein older adults should consume, and this topic is continuously debated, but many studies have suggested that increasing the amount to 1-1.2g/kg of body weight/day would minimize health problems associated with protein deficiency (Wolfe et al., 2008; Houston et al., 2008; Volpi et al., 2013). Unfortunately, many older adults do not even reach the RDA (Rousset et al., 2003).

One of the most significant problems associated with inadequate protein consumption is sarcopenia. Although there are many definitions, sarcopenia generally refers to a loss of both muscle mass and function (Beasley, Shikany & Thomson, 2013; Fielding et al. 2011). It occurs when there is an imbalance between muscle protein synthesis (MPS) and muscle protein breakdown (MPB; Phillips et al., 2009). Many factors are responsible for causing sarcopenia,
including disuse, changing endocrine function (due to hormones), chronic diseases, inflammation, insulin resistance, and nutritional deficiencies, mainly caused by protein deficiency (Fielding et al., 2011).

Sarcopenia leads to a number of complications, such as increased risk of falls (Forrest et al., 2006). In fact, falls are one of the major causes of hospitalization and health care expenditures in older adults. It has been estimated that falls are responsible for a significant portion of injuries (65%), injury-related hospital admissions (84%), and also injury-related mortality (58%) among the older population, leading to a cost of approximately $1 billion per year (Health Canada, 2002). Sarcopenia is also associated with decreased functional status (Fielding, et al, 2011). It has been suggested that higher-protein intake combined with resistance exercise training (RET) can help combat sarcopenia (Han, 2008). However, because exercising can be challenging for older adults (Schutzer & Graves, 2004), diet becomes an important factor in order to improve the quality of life of older adults, especially protein consumption. Increasing protein consumption through food fortification can play a key role in this process. Food fortification can cause many changes to the sensory properties of a food, for this reason, verifying how these changes affect food intake of older adults is very important. Therefore, the purpose of this study is to develop puddings fortified with soy and whey proteins with acceptable sensory properties in order to improve protein intake in older adults.
CHAPTER 2- LITERATURE REVIEW

2.1 Older adults and malnutrition

It is commonly accepted that sensory perception decreases with aging (Field, 2016). It has been reported that this age is when sensory perception starts to change (Mojet, Heidema & Christ-Hzelhof, 2003). Failure in audition, vision, olfaction and gustation are many of the sensory problems that happen with ageing (Elsner et al., 2002). The reduction in sensory perception most likely contributes to diminished appetite by removing the positive stimuli for feeding. Therefore, the feeling of fullness and early satiety through meals is likely to happen sooner among older adults (Visvanathan & Chapman, 2009).

Many older adults present losses in chemosensory abilities as they age, meaning that the perception of chemical substances, for example odor detection, is reduced. This, negatively impact their psychological and physiological abilities. Furthermore, a loss in palatability of food, seen among older adults can affect their behavior towards signals of hunger (Le Magnen, 1977). According to Tepper & Genillard-Stoerr (1991), older adults also show loss of their desire for common foods. This decreases their nutritional status, leading to malnutrition.

Many older adults have difficulties obtaining adequate protein from their diet alone, as there is a tendency to consume less food with aging (Houston et al., 2008). In order to improve their nutritional status, many supplements exist in the market today, such as oral nutritional supplements (ONS), which are liquid foods that are consumed by older adults with nutrient deficiencies or medical condition. However, older adults may find it hard to consume enough of these supplements to be beneficial for health. Some of the reasons include taste and the volume
required; make it difficult for this population to consumer enough protein supplements to improve their health status (Stratton et al., 2003; Milne et al., 2005).

Using a food first strategy by providing foods that are more nutritionally dense is beneficial for this population, as it allows older adults to consume a greater amount of calories as well as micro and macronutrients without increasing volume (Trabal et al., 2014). This can be accomplished by including foods in the diet that are naturally high in protein, or through the addition of protein to foods that are commonly consumed by older adults. This is termed fortification and the benefits of protein fortification have been well documented (Stelten et al., 2015; Tsikritzi, et al., 2014).

According to the WHO (2006), fortification is defined as “the addition of one or more essential nutrients to a food whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups.” Essentially, the nutrient content of the foods is enhanced in some way.

A study conducted by Castellanos, Marra & Johnson (2009) in a nursing home facility, showed the effect of food enhancement on increasing nutrient intake by older adults. Food enhancement was completed by making the recipes more “rich”, meaning adding butter to a hot cereal (breakfast food), soup and potato dish. Extra protein in the form of dairy and eggs was also incorporated into the recipe. However, this protein addition was not sufficient to increase protein intake, especially for older adults that were not “big eaters.” Therefore, in order to achieve better results when increasing protein intake, fortification of foods with extra protein such as whey or soy should be considered. This will be the focus of the current research.
2.2 Health Benefits of Soy and Whey Protein

An adequate amount of protein intake by older adults can play a key role in reducing malnutrition and many of the diseases associated with it such as sarcopenia. Many types of protein have a positive effect on stimulating MPS and maintaining muscle mass (Symons et al., 2007; Young et al., 1984). However, the majority of studies on muscle synthesis and maintenance to date have focused on whey and soy protein sources because they are frequently used for supplementation and fortification purposes (Phillips et al., 2009). Both protein sources are considered effective in preventing and treating sarcopenia, and malnutrition, with each having its own strengths and limitations. Besides having positive effect on stimulating MPS, soy and whey proteins also present other health benefits.

2.2.1. Soy Protein

Soybeans (Glycine max) are part of a leguminous family along with clover, peas, and alfalfa (Singh et al., 2008). The nutritional components of the bean include vegetable protein, complex carbohydrates, dietary fibers, oligosaccharides, isoflavones and minerals (Anderson et al, 1999).

Soy protein is considered a “complete” protein, as it is a source of all essential amino acids (EAAS), such as lysine, which is deficient in the majority of cereals (Young, 1991; Dhingra & Jood, 2004). It also has a high digestibility (104%), but presents a lower Net Protein Utilization (NPU) (72%) and less leucine (62%) than whey (Phillips et al., 2009). NPU is the proportion of protein intake that is retained. Amino acid composition of soy is presented in Table 2-1.

Soy protein has been associated with a variety of health benefits. It has been suggested that when vegetable protein sources, such as soy, are substituted for animal protein, blood
cholesterol levels are reduced (Sirtori et al., 1993). According to Nagata et al. (1995), this is approximately 2% to 3% reduction. Cholesterol lowering effects provided by soy protein protect against coronary heart disease (Tikkanen & Adlecreutz, 2000). According to Anderson et al., (1995), for every 1% of cholesterol reduction, the risk of heart diseases is reduced approximately 2% to 3%. Moreover, the FDA (Food and Drug Administration, 1999) allows foods containing a minimum of 6.25 g of soy protein per serving to hold a health claim “soy protein combined with a diet low in saturated fat and dietary cholesterol may reduce the risk of coronary heart disease" (FDA 1999).

Soy protein has also been found to have a positive effect on preventing osteoporosis. According to Erdnann & Potter (1997), when 40 g/day of soy protein isolate was consumed by research participants during a 6 months period, both mineral content and lumbar spine density, were significantly increased. Furthermore, it has been shown that consumption of soy protein decreases urinary calcium loss, compared to a mixed of animal protein or whey (Anderson et al., 1987; Breslau et al., 1988). Other health benefits of soy protein include anti-aging effects (Chiu et al., 2009) and protection against postmenopausal breast cancer (Boucher et al., 2013).

2.2.2. Whey Protein

Whey is a derivative product of cheese and casein fabrication, and represents about 20% of the original milk protein content (McIntosha et al., 1998). Whey protein has a high protein quality score and contains large amounts of Branched-Chain Amino Acids (BCAA) in its composition (Garlick & Grant 1988), such as leucine. BCAAs donates –NH₂ in skeletal muscle, where the greatest amount of their transamination occur (Harper et al., 1984).

Whey proteins are rich in leucine (108mg/g) and present high digestibility (115 mg/g) and NPU (92 mg/g) scores, compared to soy (Phillips et al., 2009; Table 2-1). The high leucine
content in whey has been linked to MPS (Anthony et al., 2001). The capacity of whey protein for promoting MPS also comes from its overall amino acid profile. The amino acid profile of whey protein is very similar to the skeletal muscle; whey offers almost all amino acids in the same proportion that is required for MPS (Bergstrom et al., 1974; Rasmussen et al., 2000).

Besides stimulating MPS, whey protein helps on the achievement of a desirable body composition (Haa, 2003). Some studies suggested that this could be due to the satiating effect of milk and certain derived peptides (Luhovyy, Akhavan & Anderson, 2007).

Benefits involving the immune system have also been associated with whey protein (Shah, 2000). Athletes in intense training can benefit from incorporating whey protein into their daily diet, as studies have reported that they experience an immunosuppressive effect of vigorous or excessive training (Nieman, 2001). Furthermore, it has been shown that whey protein present antibacterial and immune protection against disease in newborns (McIntosha et al., 1998). These benefits should be explored in older adult populations as they often suffer from decreased immunity (Kiecolt-Glaser & Glaser, 2002).
Table 2-1: Amino Acid Composition of soy and whey protein (Adapted from Phillip et al., 2009)

<table>
<thead>
<tr>
<th>Amino Acid content (mg/g)</th>
<th>Isolated Whey Protein</th>
<th>Isolated Soy Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histidine</td>
<td>20</td>
<td>28</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>76</td>
<td>44</td>
</tr>
<tr>
<td>Leucine</td>
<td>108</td>
<td>62</td>
</tr>
<tr>
<td>Lysine</td>
<td>101</td>
<td>62</td>
</tr>
<tr>
<td>Methionine</td>
<td>48</td>
<td>20</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>67</td>
<td>88</td>
</tr>
<tr>
<td>Threonine</td>
<td>44</td>
<td>32</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>26</td>
<td>10</td>
</tr>
<tr>
<td>Valine</td>
<td>72</td>
<td>54</td>
</tr>
<tr>
<td>PDCAAS (branched-chain amino acids)</td>
<td>115</td>
<td>104</td>
</tr>
<tr>
<td>NPU (net protein utilization)</td>
<td>92</td>
<td>72</td>
</tr>
</tbody>
</table>

2.3. Functional Properties of Soy and Whey Proteins

Whey and soy protein are used in a variety of products due to their functionally, and nutritional properties. There are various physical forms for each of these protein sources, each presenting unique sensory and functional attributes (Russel et al., 2006).

2.3.1. Soy protein

Soy protein has been used as a nutritional and functional ingredient in a variety of products. Benefits of incorporating soy ingredients into food products include moisture and flavor retention, emulsification support, and also texture improvement (Miller, 2005).
The most common forms of soy protein used as supplements or to fortify foods include soy flours/grits, Soy Protein Concentrates (SPC), and Soy Protein Isolates (SPI). The amount of total protein content in these forms varies from 40% to 90% (Wolf, 1970).

Flours and grits are the minimum refined form of soy protein. Their content of fat, particle sizes and texture can vary from product to product. They can be used in a variety of food such as baked goods, tofu, and soymilk. One of the disadvantages of soy flours/grits is the taste and mouthfeel of products made with them, such as beany taste and astringent mouthfeel, for example. SPC present higher amount of protein than flour/grits, around 70% or more on a moisture-free basis. They also can present variation in water and fat absorption. Baby foods, cereals, dry food mixes, milk replacers, pet foods and snacks are some examples of products where soy concentrates are used. Lastly, SPI present the highest amount of protein, ranging from 90% or more (Singh et al., 2008). The fact that SPI’s are a good source of protein, are rich in lysine, present bland flavor, and decrease flatulence and sugar content, make them very valuable to improve product quality. Soy isolates are used in a variety of products, with meat protein replacement being the most common usage. The most common forms of soy protein are found in Table 2-2.
Table 2-2: Most common forms of soy protein

<table>
<thead>
<tr>
<th>Common forms of Soy</th>
<th>% of protein in each form</th>
<th>Food Usage</th>
<th>Functional Properties</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour/grits</td>
<td>40% to 54%</td>
<td>baked goods, tofu, soymilk,</td>
<td>Emulsification (formation and stabilization), promotion and prevention of fat absorption, water retention and uptake, viscosity, chip and chunk formation, shred formation, dough formation, cohesion, adhesion, etc.</td>
<td>Yasumatsu et al., 1972; Wangs &amp; Zayas 1991; Singh et al., 2008</td>
</tr>
<tr>
<td>Concentrate</td>
<td>~70%</td>
<td>Baby foods, cereals, dry food mixes, milk replacers, pet foods, snacks</td>
<td>Emulsification (formation and stabilization), promotion and prevention of fat absorption, water retention and uptake, viscosity, dough formation, adhesion, etc.</td>
<td>Wangs &amp; Zayas, 1991; Singh et al., 2008</td>
</tr>
<tr>
<td>Isolate</td>
<td>≥90%</td>
<td>Meat protein replacement, whipped toppings, frozen desserts</td>
<td>Emulsification (formation and stabilization), promotion of fat absorption, viscosity, gelation, fiber formation, shred formation, dough formation, cohesion, adhesion, elasticity, aeration, etc</td>
<td>Malhotra &amp; Coupland, 2004; Singh et al., 2008</td>
</tr>
</tbody>
</table>
2.3.2. *Whey protein*

Recently, milk components have become recognized as functional foods, suggesting their use has a positive effect on health outcomes that can be measured (Gill et al., 2000). Whey proteins are largely used in dairy products (Akalin et al., 2012), and also as a fat substitute in soups, desserts and bakery products. Another application of whey includes its use in meat replacements to avoid any fat loss during cooking (Asghar et al. 2009; Ensor et al. 1987).

Both whey protein concentrate and isolate provide valuable physical properties to foods, such as emulsification, gelation, water binding, solubilization, whipping/foaming, and viscosity development (Walsem et al., 2002). Besides giving structure and facilitating aggregation in foods, they are highly soluble over an extensive pH range, which makes them valuable in food products (Walzem et al., 2002). The most common forms of whey protein are represented in Table 2-3. Furthermore, whey proteins have also been used for functional and nutraceuticals purpose (Agriculture and Agri-Food Canada, 2008a, b) due to the composition of essential amino acids, which are responsible for building blocks of muscles and other health tissues. Those benefits include enhancing athletic performance, supplementing infant formula, helping build and maintain muscle mass in older adults (Russel et al., 2006; Phillips et al., 2009).
Table 2-3: Most Common Forms of Whey Protein

<table>
<thead>
<tr>
<th>Common forms of Whey</th>
<th>% of protein in each form</th>
<th>Food Usage</th>
<th>Functional Properties</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet</td>
<td>-</td>
<td>-</td>
<td>Bleaching efficacy</td>
<td>Jervis et al., 2015</td>
</tr>
<tr>
<td>Acid</td>
<td>-</td>
<td>bread, biscuits, crackers, snack foods</td>
<td>Enhancement of color and flavor</td>
<td>Kosikowski, 1979</td>
</tr>
<tr>
<td>Concentrate</td>
<td>34%, 50% or 80% w/w protein</td>
<td>meat luncheons, sausages, soups, desserts, milk products, infant formulas, sports nutrition</td>
<td>Foaming, aeration, emulsification, fat binding, gelation capacity, heat stability, solubility, etc.</td>
<td>Russell et al. 2006, Richert 1979, Surh et al. 2006, Hoffmann &amp; Van Mil 1999, De Wit 1990</td>
</tr>
</tbody>
</table>
2.4. Utilization of Pudding for Protein Fortification

Food intake is influenced by food preference. Thus, it is important to fortify foods that are likely to be consumed by older adults. Often older adults prefer foods with high carbohydrate content and sweet taste (van der Meij et al., 2012). They also look for foods with textures that are easy to eat (Roininen et al., 2003). Pudding was chosen for this study because it is a cream-based dessert and it is easy to swallow. The texture also makes this dessert suitable for many older adults who present dysphagia problems, as well as individuals who consume normal foods. Creamy foods also have an advantage of reducing the risk of choking (Ilhamto et al., 2014). Soy and whey were utilized to fortify the chocolate puddings due to their functionally in foods, and also their health benefits, which make these two proteins suitable to be added in diverse types of foods.

2.4.1. Determine fortification levels of proteins

Previous studies have not yet justified protein levels to be added in foods (Drake et al., 2000; Tsikritzi et al., 2014), meaning that researches add protein into food without explaining the reason why they have added the amount utilized. One of the only studies where the amount of protein was justified was conducted by Friedeck, Karagul-Yuceer & Drake (2003). In this study, inclusions of 0%, 2% and 4% of SPI were used to fortify low-fat dairy-based ice creams. According to the authors, the 4% SPI addition was used for consumer testing because it had enough soy protein to be considered “source of protein” for labeling purposes, while the 2% did not.
Due to the fact that there are no standardized amounts of protein to add into food regarding to fortification, protein health claims recommended by Health Canada were adopted for this study as a guide to calculate protein in the puddings. From a practical perspective, if these puddings were ever made commercially, the protein level would allow for a protein related health claim to be made on packaging.

The Canadian Food Inspection Agency (CFIA) (2014) considers four health protein claims referring to the amount of this macronutrient on foods. A food product is considered “low in protein” when the food contains no more than 1g of protein per 100g of the food. For a food product be considered “source of protein” the food has to have a Protein Rating (PR) of 20 or more, as determined by official method FO-1 (Determination of Protein Rating), per reasonable daily intake, found at Schedule K (Ministry of Justice, 2015). According to CFIA (2014), the PR of a food is established on the amount of protein in a reasonable daily intake of a food item. It is calculated by “multiplying the quantity of protein present in a Reasonable Daily Intake of the food by the quality of the protein, which is the Protein Efficiency Ratio (PER) of the food.” The claim for “excellent source of protein” can be made when the food has PR of 40 or more, as determined by official method FO-1 (Determination of Protein Rating), or per reasonable daily intake, found in Schedule K (Ministry of Justice, 2015). Lastly, to be claimed as “more protein” the food has to have a PR of 20 or more, as determined by official method FO-1 (Determination of Protein Rating), or per reasonable daily intake, found on Schedule K (Ministry of Justice, 2015) or if the food contains at least 25% more protein, totaling at least 7 g more, per reasonable daily intake than a reference food of the same food group or a similar reference food. For this research, the aim will be to fortify the puddings with enough protein to achieve a PR of 20 or more.
2.5. Effect of protein addition on perceived sensory properties

Fortification of food with protein can be effective for increasing protein intake. A recent single blind controlled trial study found that the use of protein to fortify foods, such as bread and yogurt, as part of a daily meal, was effective in increasing the amount of protein consumption in ill patients (Stelten et al., 2015). However, it is important to understand the changes to the sensory properties of the foods caused by added proteins (soy and whey). Changes in taste and texture of the fortified foods can have an impact on liking, and consequently on food intake by older adults. Flavor and aroma are the main factors that directly impact food intake by the older adult population; however, other factors can also be important in their decision to consume a food (Elsner, 2002). For example, texture can be more preferred than flavor and aroma, especially when food is bland (Szczesniak, 1990). Therefore, the effect of protein addition on the sensory properties of foods as well as liking of the foods needs examining.

Many of the studies examining liking/acceptability of protein fortified foods include sensory panels that are performed with a younger population, ranging in age from 19-50 years. For example, Childs et al. (2007) evaluated the sensory properties and consumer acceptance of whey and soy proteins in meal replacements, such as bars and beverages, using younger individuals. The type of protein had a significant impact on the sensory properties of the foods. Meal replacements bars made with whey were categorized as having increased sweet aromatic, cardboard flavor notes and bitter taste. The bars made with only soy was categorized as having higher intensities of nutty, cereal, and hay flavors. Bars made with both proteins were characterized lower in sweet aromatic flavor but higher in hay flavor intensity. Meal replacements containing whey or a mixture of whey and soy protein had higher consumer acceptance compared to those containing just soy. In a study that evaluated only the liking of
cookies prepared using soy ingredients (soy flour, soy isolate and soy concentrate), results showed that the cookies fortified with soy flour (Intsoy TSP) and soy protein concentrate had the highest overall liking score (Chen et al, 2003).

Previous sensory studies have shown the effect of protein addition on liking within younger adults. However, given that failure in audition, vision, olfaction and gustation are many of the sensory problems that happen with ageing (Elsner et al., 2002; Mojet, Heidema & Christ-Hzelhof 2003); the older adult population must be included in sensory testing. To date, few studies have done this. Tsikritzi et al. (2014) evaluated the sensory properties of biscuits fortified with macronutrients (soy and whey proteins) and micronutrients using a trained panel of younger individuals, as well as the liking of these foods using older adult consumers. Results showed significant changes in the sensory attributes of the fortified biscuits. Changes in liking, however, were not observed, despite all the sensory changes identified. This observation could mean that either, a younger trained panel was more sensitive than the older adults at detecting all the sensory changes, or that these changes did not affect their liking for the fortified biscuits.

More studies must be conducted which correlate liking collected using older adults with the sensory profile of the fortified products. This is important in order to develop products that are appealing to consumers.

2.6. Sensory Evaluation

A review discussing sensory methods using older adults have recently been completed (Methven, et al., 2015). Challenges when performing sensory testing with this population is likely to happen due to a number of factors such as visual and hearing difficulties, use of medication that influence the product assessment, fatigue caused by large samples sizes, and low
cognitive capacities. All these factors prevent reliable results from being collected (Methven, et al., 2015). Therefore, the use of simpler methods when working with older adults may be more effective. Hedonic testing is one of the simplest methods to be performed with older adults because it does not require efforts on memorization or interpretation of scales (Methven, et al., 2015). This test evaluates the overall liking of food products for appearance, taste and texture using the 9 point hedonic liking scale that ranges from 1 (‘Dislike Extremely’) to 9 (‘Like Extremely’). It is the technique that is most commonly used when determining consumer liking of food products (Mashayekh, Mahmoodi, & Entezari, 2008).

Check-All-That-Apply (CATA) is a relatively new sensory test that provides a good product characterization according to the sensory perception of consumers (Adams et al., 2007). CATA has been used with many demographic groups to describe a variety of products (Ares et al., 2010; Dos Santos et al., 2015). CATA is a simple, quick and easy method to collect information about a food product (Scott, 2016). This method consists of a list of attributes from which individuals select those they think best describe a certain product (Ares et al., 2010). This test is powerful for discriminating between two samples (Valentin et al, 2012).

One of the disadvantages of CATA relates to the organization of its list. It can be challenging to optimize a list that contains all of the necessary attributes while being concise. A study conducted by Hughson & Boakes (2002) showed that keeping the list simple and short rather than long was better for providing descriptions of a set of wines. One of the common means of choosing the words to include on the list is to base it on previous studies, and provide the participants the option of adding any other attribute they think could be suitable to describe the samples. Studies have shown that CATA questions and liking acceptance can be combined without causing bias (Ares & Jaeger, 2015; Jaeger et al., 2013). However, in order to obtain a
more meaningful characterization of the samples, other sensory methods need to be performed with younger population.

A method recently developed for characterizing samples known as napping, consists of “collecting the sensory distance perceived between products by positioning the products on a sheet of blank paper (a tablecloth or “nappe” in French language)” (Perrin & Pages, 2009). With napping, products are categorized according to the distance between them; products positioned close or far from one another are considered to have similar or different properties, respectively. Similar to other methods, the napping test also presents some disadvantages. If the number of samples is higher than 10, it could generate fatigue for the participants, also, this test has to be completed using other methods when attribute intensity is desired (Page, 2003, 2005a). However, napping is a good method to evaluate a product as a whole and to give rapid sensory information regarding a product (Ares et al, 2011). In this study, napping will be used to screen sensory attributes for the CATA test.

Descriptive analysis is the “gold standard” sensory method that provides the best description of the sensory qualities of food. It uses a trained panel with a small number of panelists (from 8 to 15) to assess attributes and their intensity (Valentin et al, 2012). It is widely used to compare samples in distinct moments in time, to compare different sets with some samples in common and to obtain very detailed and precise sensory profiling of food products (Varela & Ares, 2012). Through a trained panel it is possible to determine the effect of fortification on sensory properties of a food. Because it is a standard sensory technique, descriptive analysis is regularly used for the evaluation of many food products (Childs et al., 2007). Some of the disadvantages of this method include the fact that it is time demanding and can be costly (Drake, 2007).
Through the use of various sensory techniques, it will be possible to collect reliable information from older adults about sensory perception of fortified about food products. This information will allow for the identification of proteins and levels of the proteins within pudding formulations which is most liked by these consumers.
CHAPTER 3- RATIONALE AND RESEARCH OBJECTIVES

As outlined in Chapter 1 and 2, problems with malnutrition and loss of muscle mass, mainly caused by protein deficiency, are serious problems among the older adult population. Improving food sensory attributes, such as taste and texture, can be an important approach to increase acceptability and, consequently, food intake by older adults. Despite the functional and health benefits of whey and soy protein, very little information is available regarding the impact of fortification of these two proteins in combination or alone on the sensory properties of food products, especially in puddings. The changes that occur because of fortification are important to ensure that they do not have a significant impact on liking.

The few studies that evaluated the effects of soy and whey proteins on foods, focus on the liking acceptance or on the sensory profiling (sample characterization) of the foods. Due to a lack of comparison between liking acceptance and sensory profiling, specific sensory changes responsible for decrease or increases in liking are not well understood. Moreover, the majority of the studies use younger individuals for sensory testing. However, it is important to understand the effects of food fortification among older adults, since protein deficiency is much more common among this population. Furthermore, understanding the attributes responsible for liking is very important in order to develop a better quality and appealing product.

The aim of this study was to develop puddings fortified with soy and whey proteins with acceptable sensory properties as a means of improving protein intake in older adults. The null hypothesis is that addition of soy and whey protein in pudding formulations would have no effect on consumer liking; and the alternative hypothesis is that the addition of soy and whey protein in pudding formulation would have a negative or positive effect on consumer liking. This research
will investigated sensory changes in the puddings formulated with different concentrations of soy and whey protein using the rapid profiling techniques, of napping and Check-All-That-Apply (CATA), as well as liking/acceptance test and a descriptive sensory test. The effect of these changes will be tested in an older adult population as well as their perception of the sensory attributes using the CATA test. The research aim will be achieved by the following objectives:

1) To develop protein fortified puddings that are eligible for a health claim “more protein” according to the Canadian Food Inspection Agency (CFIA).

2) To characterize the pudding formulations to understand the effect of protein addition on the nutritional and sensory properties of the puddings.

3) To determine how changes in the sensory properties of the puddings will impact liking of this food by older adults.
CHAPTER 4- DEVELOPMENT AND CATEGORIZATION OF THE PUDDING FORMULATION

4.1 Introduction

Food intake often decreases with age. Consequently, older adults frequently experience loss of muscle mass, known as sarcopenia, as well as protein-related deficiencies that lead to malnutrition (Phillips, Chevalier, & Leidy, 2016). A number of strategies have been utilized to prevent those health problems and one such approach is food fortification. Fortification refers to the process of increasing the nutrient content of foods. Many people have historically fortified foods with proteins (Mashayekh et al., 2008; Tsikritzi et al., 2015; Tsikritzi, Moynihan, Gosney, Allen, & Methven, 2014). When doing this, it is important to consider both protein level and protein quality when increasing protein levels. High quality proteins are considered very digestible and contain all the essential amino acids that the body requires to build and maintain muscle mass (McNeill & Monroe, 2008). Soy and whey protein are both considered high quality protein, and both have been shown to have a positive effect on combating sarcopenia, as well as malnutrition by stimulating muscle protein synthesis (Tsikritzi et al., 2015).

When fortifying foods for older adults, it is important to select a food category that is commonly consumed by all. According to a study conducted by Lam (2014), older adults living in Long Term Care Homes (LTC), and individuals who prepare foods for them, suggested desserts as the most preferred foods to be fortified. Therefore, for this study pudding was selected as the food for fortification, as it is popular dessert item in LTC.
Fortification with protein is common in dairy products (Drake et al., 2000; Friedeck, Karagul-Yuceer, & Drake, 2003), but less common in other types of foods. Recently Tziriki et al (2014; 2015) fortified sauces and biscuits with protein. Protein fortification in sauces resulted in increasing bitterness; however the fortified tomato sauce was less thick, dark, lumpy, grainy and gelatinous than the controlled sample. When biscuits were fortified with proteins, the perceived dairy flavor increased. It is obvious that fortification of products with protein results in different sensory changes for each product, therefore, sensory studies have to be conducted on every product that protein is added to. Even though food fortification is a good strategy to improve protein intake, it is important to understand the impact of this nutrient on the sensory properties of the food.

In order to estimate an adequate amount of protein on the food being fortified, a good experimental design is required. The Taguchi method was created in the 1950’s and it has been widely used in quality and product improvement. This is a type of experimental design that uses a table and simple graphics to determine the main effects of an experiment. The table is represented by $L_{n}(S)^{m}$, where “$n$” is the number of test runs, “$S$” is the number of levels (i.e. low or high) and “$m$” is the number of test factor. The Taguchi method just uses a portion of the significant levels and factors in the experimental design, reducing the number of experiments required, meaning that it is a fractional factorial design as well as the time consumed.

The objective of this research is to examine the effect of protein addition on the nutritional and sensory properties of chocolate pudding using a Taguchi design to assist with efficient experimental design. Descriptive analysis was used to evaluate sensory properties of the puddings.
4.2 Methods

4.2.1 Development of chocolate pudding

A total of eight different chocolate pudding formulations were developed in the metabolic kitchen located in the Human Nutraceutical Research Unit, University of Guelph. They were made utilizing corn starch (Ingredion, Novation Prima 300), unsweetened cocoa powder (No Name), commercial sugar, natural vanilla extract, Whey Protein Concentrate (WPC) (Saputo, 80% Instantized/ Lot #8250130012 036), Soy Protein Concentrate (SPC) (ADM, Arcon S, lot # 14120536) and Soy Protein Isolate (SPI) (ADM, ProFam 891, lot #: 15052271). Milk 2% was added to the formulation to bring the proportions to 100%.

The puddings were prepared following and L$\textsubscript{8}$$\textsuperscript{2}$$\textsuperscript{7}$ Taguchi design (Arteaga et al., 1994). An example of the L$\textsubscript{8}$$\textsuperscript{2}$$\textsuperscript{7}$ design is represented in Table 4-1. The L$\textsubscript{8}$$\textsuperscript{2}$$\textsuperscript{7}$ design means that the experiment has a table of numbers containing eight rows and seven columns, with up to seven two-level variables (Rao et al., 2008). The rows (1 to 8) represent the samples, and P$\textsubscript{1}$ to P$\textsubscript{7}$ represent the variables. The levels are represented by 1 and 2, meaning low and high concentrations of each variable.

Table 4-1: Taguchi L$\textsubscript{8}$$\textsuperscript{2}$$\textsuperscript{7}$ design

<table>
<thead>
<tr>
<th>Experiment (samples)</th>
<th>P$\textsubscript{1}$</th>
<th>P$\textsubscript{2}$</th>
<th>P$\textsubscript{3}$</th>
<th>P$\textsubscript{4}$</th>
<th>P$\textsubscript{5}$</th>
<th>P$\textsubscript{6}$</th>
<th>P$\textsubscript{7}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Seven two-level variables were considered in this study: corn starch, unsweetened cocoa powder, sugar, vanilla extract, WPC, SPC and SPI. The percentage of each ingredient used for each sample in the experimental design is shown in Table 4-2.

**Table 4-2: Percentage of ingredient composition of the eight chocolate puddings formulated following a L$_8$ 2$^7$ Taguchi design**

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Milk 2% (up to 100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples</td>
<td>Corn Starch</td>
<td>Cocoa Powder</td>
<td>Sugar</td>
<td>Vanilla Extract</td>
<td>Whey Protein Concentrate</td>
<td>Soy Protein Concentrate</td>
<td>Soy Protein Isolate</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
<td>14</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
<td>14</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3</td>
<td>16</td>
<td>0.5</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>3</td>
<td>16</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>2</td>
<td>16</td>
<td>0.5</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>2</td>
<td>16</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>3</td>
<td>14</td>
<td>0.5</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>3</td>
<td>14</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

The puddings were prepared by mixing all the solids ingredients together, then adding milk and cooked at 250° C on a hot plate (Isotemp/Fisher Scientific). All the puddings were cooked until all reached a similar end point viscosity, which was between 11000-13000 centipois (cP). This was the value of the control pudding, which is the ideal product. The viscosities of the other puddings were made to match the viscosity of the control. A further description of the pudding viscosities is described in section 4.4.2. The viscosity was measured using the Brookfield Viscometer.

After the formulations were prepared, they were put into plastic beakers, closed and cooled at room temperature, covered and refrigerated for 24h prior to evaluation. After this time,
the samples were placed into Styrofoam cups, labeled using random 3-digit codes, lidded and served at room temperature (around 25 °C).

The CFIA health claim for “more protein” as discussed in section 2.4.1 was used as a guide to determine the amount of protein used to fortify the puddings, since there is not yet a reference value of proteins for fortification purposes for any type of food.

The protein rating (PR) for each pudding was calculated by the following formula:

\[ PR = PRDI \times PER \]

where

\[ PRDI = \text{percent (\%)} \times \text{reasonable daily intake of the food} \]

The reasonable daily intake of puddings varies from 80-140g (CFIA, 2014). For this experiment 130g of pudding was considered as a serving size. Dried whey, soy protein and milk have PER of 2.6, 2 and 2.5, respectively. The calculations are found in Appendix A. Addition of protein to reach a PR of 20 or greater was the target. This would allow for a health claim for “more protein” according to CFIA.

4.2.2 Characterization of the Chocolate Puddings

4.2.2.1 Instrumental Analysis

Viscosity, moisture and ash were assessed for each pudding sample, as well as the macronutrients content (protein, fat and carbohydrates).
Viscosity

Viscosity of each sample was measured using the Brookfield Viscometer LV-RVF rotary viscometer (Brookfield Engineering Laboratories, USA) with spindle S06 and 30 RPM speed. Approximately 500 ml of pudding, at room temperature, was put into a 600 ml beaker and the viscosity of the samples was measured after two minutes. This time was chosen because the readings on the machine were more stabilized within two minutes. Samples were tested in duplicates (Appendix B).

Moisture

Moisture content was measured by placing approximately 3-4g of the samples into aluminum discs and oven-drying at 90°C for 24h. The samples were cooled to room temperature in a desiccator, and then weighted. The difference before and after drying was used to calculate the moisture content (AOAC 2000; AOAC method 923.03). Moisture content was conducted in duplicate.

Ash

The ash content was measured by placing approximately 3g of the pudding samples, into ceramic crucibles and incinerating in a muffle furnace at 550 °C for 5 hours (AOAC, 2000; AOAC method 923.03). After samples were cooled to room temperature in a desiccator, the crucibles were weighted. The difference in weight before and after drying was used to determine the ash content. Ash content was conducted in duplicate.
**Protein**

Protein was analyzed using the Dumas method. Approximately 0.2g of each pudding sample was weight in tin foil cups and the Total Nitrogen was determined via nitrogen combustion method (FP-528, Leco Corp, St Joseph, MI, USA). The amount of protein was calculated by multiplying total nitrogen by the conversion factor of 6.25 (AOAC, 2000; AOAC method 992.15). Protein content was tested in duplicates.

**Fat**

For fat measurement a semi-continuous solvent extraction method (Soxhlet) was used. Approximately 4g of pudding was put into cellulose thimbles and spread along the bottom of thimble. Glass wool was inserted to close off the top of thimbles that were put into Soxhlet extractors with a flat-bottomed boiling flask containing petroleum ether (solvent). After 5 hours of extraction, the flasks were dried in hot air oven (80°C), cooled in a desiccator, and weight. The fat content was calculated by subtracting the weight of the empty receiver flask from the weight of the flask containing residual oil remaining after drying (AOAC, 2000; AOAC method 960.39). Fat content was tested in duplicates.

**Carbohydrate**

The carbohydrate content of each pudding was measured by subtracting the sum percentage of protein, fat, ash and moisture from 100 (AOAC Method 925. 10).

**4.2.2.2 Sensory Analysis**

This experiment was approved by the research ethics board at the University of Guelph (REB # 15MY007). In order to determine sensory differences of the pudding formulations
Descriptive analysis was used. This technique requires 8-12 panelists who are trained to give the best descriptors and intensity of the samples being evaluated using a 15cm line scale. The duration of the training varies between 10-15 days and it is completed of one-hour session (Lawless & Heymann, 2010).

The reason for choosing a trained panel is because of the ability of the panel to identify small changes in sensory attributes. Moreover, a trained panel provides great quality assessment of products and is able to objectively quantify changes in sensory attributes (Valentin et al, 2012).

**Descriptive Analysis**

A total of 12 trained panelists were recruited for this experiment through the Food Science Department at the University of Guelph. They evaluated a total of 8 different chocolate pudding samples as outlined in Section 4.2.1.

Prior to starting the test, a consent form and an information sheet with details about the test and the ingredients used were given to each participant (Appendix C). The panelists had a chance to familiarize themselves with the samples for a better evaluation. Small amounts of pudding were served in plastic cups at room temperature, labeled with 3-digit random codes, to avoid any bias. Preliminary training was conducted in order to ensure that all relevant attributes and references values were included.

After participants were familiarized with the samples, they were then trained to evaluate the samples for intensity of each attribute. For each attribute, a definition and a description sheet of how to evaluate the samples were provided to each panelist. This was followed by ranking tests, which allows the panelists to become familiar with the order of intensity of the attribute. Finally,
scaling was introduced where participants evaluated the samples for intensity of the attribute. The training was conducted until the attributes were agreed by all the panelists. Definitions of the selected flavor and texture attributes, along with references samples were given to all panelists (Table 4-3 and Table 4-4).

Testing was conducted in sensory booths using red lighting to cover any difference in appearance. The samples were served in plastic cups at room temperature, labeled with 3-digit random codes. During the test, each of the attributes was evaluated using a 15-cm line scale (Lawless & Heymann 2010). Panelists placed a mark on the scale from 0-15cm, according to the perceived intensity of each attribute. Water and sliced apples were given to panelists to cleanse their palate between each sample. The panelists had 2 minutes intervals between evaluating each sample. All data was collected using Compusense software, Compusense 5.0 (Compusense, Guelph, ON, Canada).

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Rating scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet</td>
<td>Basic taste stimulated by sugar</td>
<td>0= low sweet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15= high sweet</td>
</tr>
<tr>
<td>Chocolate flavor</td>
<td>Aromatic associated with cocoa beans</td>
<td>0= low chocolate flavor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15= high chocolate flavor</td>
</tr>
<tr>
<td>Beany flavor</td>
<td>Aromatic associated characteristic of soybeans and other legumes</td>
<td>0= low beany flavor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15= high beany flavor</td>
</tr>
<tr>
<td>Grainy</td>
<td>The amount of small, rounded particles in the surface of the sample</td>
<td>0= low grainy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15= high grainy</td>
</tr>
<tr>
<td>Thick</td>
<td>The viscosity of the product</td>
<td>0= low thick</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15= very thick</td>
</tr>
</tbody>
</table>
Table 4-4: Attribute references used for descriptive analysis of chocolate puddings

<table>
<thead>
<tr>
<th>Attribute</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet</td>
<td>Sucrose dissolved in water</td>
</tr>
<tr>
<td></td>
<td>Low: 2.5%</td>
</tr>
<tr>
<td></td>
<td>Medium: 5%</td>
</tr>
<tr>
<td></td>
<td>High: 7.5%</td>
</tr>
<tr>
<td>Chocolate flavour</td>
<td>Chocolate pudding (Control sample)</td>
</tr>
<tr>
<td></td>
<td>Low: 8g of cocoa powder</td>
</tr>
<tr>
<td></td>
<td>Medium: 11g of cocoa powder</td>
</tr>
<tr>
<td></td>
<td>High: 16g of cocoa powder</td>
</tr>
<tr>
<td>Beany</td>
<td>Cooked proteins (SPC, SPI, WPC), soy milk</td>
</tr>
<tr>
<td>Grainy</td>
<td>Speculoos, cooknotti (Penotti)</td>
</tr>
<tr>
<td>Thick</td>
<td>High and low fat yogurt</td>
</tr>
<tr>
<td></td>
<td>Low thick: Liberte mediterrane 9% fat</td>
</tr>
<tr>
<td></td>
<td>Very: Oikos Danone 0% fat</td>
</tr>
</tbody>
</table>

4.3 Statistical Analysis

4.3.1 Instrumental Analysis

One Way Analysis of Variance (ANOVA) was used to calculate the results to determine if significant differences existed among the products for each of the nutritional components (fat, carbohydrates, moisture, etc.). If significant differences were observed, then a Tukey’s Honestly Significant Difference test (HSD) was used to identify which samples were different.
4.3.2. Descriptive Analysis

The data collected from the trained panel was exported from Compusense 5.0, (Compusense, Guelph, ON, Canada) sensory evaluation software and data was analyzed using XLSTAT Version 2014.4.09 (Addinsoft 1995-2014 ©). In order to evaluate the significant difference in attribute intensity between the chocolate pudding samples (WPC, SPI and SPC) and also differences among panelists and among replicates, a three-way Analysis of Variance (ANOVA) was used. The main effects of session (SE), judge (J), sample (S), and the interactions (SE*J, SE*S, J*S) were included in the analysis. A posthoc analysis was conducted through Tukey’s Honestly Significant Difference (HSD) test to determine where significant difference existed among sample means (p<0.05).

4.4 Results and Discussion

4.4.1 Development of Chocolate Pudding

According to the experimental design, there were puddings with no protein, with a single protein source, with two proteins, and with three proteins added to them. The amount of protein to be added to the pudding was decided during preliminary tests. Anything over 9% protein addition led to puddings with unpleasant sensory properties and therefore, the upper limit was set at 9% protein addition. Table 4-5 contains the PR, total protein and more protein (comparing with the control) for each sample. Puddings with two or three proteins added to them met the requirements of “more protein” according to CFIA, since the PR was over 20. Puddings that
contained only one protein did not meet the CFIA requirements and would not be eligible for a protein health claim.
<table>
<thead>
<tr>
<th>130g serving size/ Samples</th>
<th>Ingredients (g)</th>
<th>Starch</th>
<th>Cocoa</th>
<th>Sugar</th>
<th>Vanilla Extract</th>
<th>WPC</th>
<th>SPC</th>
<th>SPI</th>
<th>Milk</th>
<th>PR</th>
<th>Total Protein (g)</th>
<th>More Protein (approximately)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.4</td>
<td>2.4</td>
<td>16.8</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>97.8</td>
<td>10</td>
<td>3.81</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>2.4</td>
<td>2.4</td>
<td>16.8</td>
<td>1.2</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
<td>86.4</td>
<td>30</td>
<td>12.98</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2.4</td>
<td>3.6</td>
<td>19.2</td>
<td>0.6</td>
<td>0</td>
<td>3.6</td>
<td>3.6</td>
<td>87</td>
<td>21</td>
<td>9.88</td>
<td>6</td>
<td></td>
</tr>
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<td>2.4</td>
<td>3.6</td>
<td>19.2</td>
<td>1.2</td>
<td>3.6</td>
<td>0</td>
<td>0</td>
<td>90</td>
<td>17</td>
<td>6.63</td>
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<tr>
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<td>3.6</td>
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<td>19.2</td>
<td>0.6</td>
<td>3.6</td>
<td>0</td>
<td>3.6</td>
<td>87</td>
<td>24</td>
<td>10.02</td>
<td>6</td>
<td></td>
</tr>
<tr>
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<td>3.6</td>
<td>2.4</td>
<td>19.2</td>
<td>1.2</td>
<td>0</td>
<td>3.6</td>
<td>0</td>
<td>90</td>
<td>15</td>
<td>6.49</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3.6</td>
<td>3.6</td>
<td>16.8</td>
<td>0.6</td>
<td>3.6</td>
<td>3.6</td>
<td>0</td>
<td>88.2</td>
<td>23</td>
<td>9.54</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>3.6</td>
<td>3.6</td>
<td>16.8</td>
<td>1.2</td>
<td>0</td>
<td>0</td>
<td>3.6</td>
<td>91.2</td>
<td>16</td>
<td>7.07</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Foot note:
WPC= Whey Protein Concentrate; SPC= Soy Protein Concentrate; SPI= Soy Protein Isolate
More protein= more protein compared to the control sample (sample 1) (approximate number)
4.4.2 Instrumental Analysis

The ANOVA results of the protein content, as measured by Dumas, revealed that there were significant differences in protein content among the samples (Appendix C). As expected sample 2 (3% WPC/3% SPC/3% SPI) and 1 (0% protein) had the highest (10.53%) and the lowest (5.25%) protein content, respectively. Sample 1 (0% protein) and 6 (3% SPC) with 5.25% and 5.59%, however did not differ significantly in protein content. Even though sample 6 had 3% SPC, the additional milk added to sample 1 contributed protein to the formulation almost up to the level of the single protein fortified samples. Additionally, despite sample 3 (3%SPC/3%SPI) and 7(3%WPC/3%SPC) having the same amount of protein added, they were significantly different. The reason might be due to the fact that WPC has less protein content, than SPC and SPI (Table 2-2 and Table 2-3).

The comparison of protein content between the calculated values using the CFIA formula and the measured protein concentration using the Dumas is found on Table 4-6. The samples were grouped according to the amount of protein added to make it easier to visualize results. The protein content according to the Dumas method was similar but a little higher compared to the CFIA formula. The reason might be that Dumas is a measurement of the entire pudding sample and takes into consideration the protein content from the other ingredients, such as the cocoa powder (around 20g protein/100g cocoa), which is not accounted for the CFIA calculations.

Due to a lower fat content on the puddings; Soxhlet method was not able to measure fat content in any of the 8 puddings. The result from instrumental analysis is found in Appendix D.
Table 4-6: Protein content using CFIA formula and Dumas method

<table>
<thead>
<tr>
<th>Samples</th>
<th>Protein (CFIA)</th>
<th>Protein (Dumas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.93</td>
<td>5.25 ± 0.02</td>
</tr>
<tr>
<td>6</td>
<td>4.99</td>
<td>5.59± 0.08</td>
</tr>
<tr>
<td>8</td>
<td>5.44</td>
<td>6.54± 0</td>
</tr>
<tr>
<td>4</td>
<td>5.10</td>
<td>6.6± 0.03</td>
</tr>
<tr>
<td>7</td>
<td>7.34</td>
<td>8.09± 0.21</td>
</tr>
<tr>
<td>5</td>
<td>7.71</td>
<td>8.44± 0.01</td>
</tr>
<tr>
<td>3</td>
<td>7.6</td>
<td>8.46± 0.07</td>
</tr>
<tr>
<td>2</td>
<td>9.98</td>
<td>10.53± 0.07</td>
</tr>
</tbody>
</table>

4.4.3. Trained panel

A summary of the ANOVA results of the trained panel evaluation is shown in Table 4-7. An evaluation of the panel performance was first carried out in order to better understand those effects as well as any significant interactions between judge*sample, judge*session and session*sample, which may have been observed.

Preliminary evaluation of panel Performance

There were no significant interaction effects between sample*session for any of the attributes, meaning that the sensory properties of the samples did not differ among the testing sessions.
However, a significant judge*sample effect was found for all the attributes, meaning that the judges evaluated the samples differently. When the interaction data plotted, all the interactions found in this panel were considered magnitude interactions. This interaction is a direct effect of differences in scale use. Panelists have different ways to score the attribute intensity, some scoring higher or lower, but following the same trend on the graphs (Appendix E-1). Such variations are not uncommon to be found even with exhaustive training of the panelists and the use of references during training (Guinard & Cliff, 1987). In addition to the significant judge interactions, a significant judge effect was found for all sensory attributes (Appendix E). This indicates that the judges were not in agreement with regard to their evaluations of the samples. It is not unusual to observe such differences, due to individual natural variation to perceive and to rate sensory attributes (King et al, 2013; Cliff et al., 2015). Judges are agreeing on the trend of low and high score on the graphs, but not agreeing on the placement of the samples on the line. For example judge 11 evaluated the sweetness of sample 1 as 14.2, and sample 2 as 4.3, whereas judge 12 evaluated sample 1 as 14.1 and sample 2 as 2.4 on the 15cm line scale.

* Descriptive Analysis of chocolate puddings

The means scores of the five sensory attributes of the chocolate puddings are found in Table 4-7. There were significant differences for five of the attributes identified: sweet, chocolate flavor, beany, grainy and thick.

Overall, high levels of fortification resulted in a decrease of sweetness, chocolate flavor, and an increase in beany flavor and a grainy texture. The chocolate pudding with no protein
fortification (sample 1) had the highest mean score for sweet (13.8) and chocolate flavor (13.9), and the lowest means score for beany (0.6) and grainy (0.6), while the chocolate pudding made with 9% protein (sample 2) had the lowest mean score for sweet and chocolate flavor, and the highest score for beany and grainy. The decrease in sweetness with addition of soy protein has been observed by other researches (Drake et al., 2000) when adding soy to yogurts, similarly beany flavor, chalkiness and thickness were also increased due to soy protein addition. Soy proteins are believed to cause an increase in soy flavors, aromas and astringency. Drake et al., (2000) have suggested that these changes may be responsible for the decrease in sweet intensity in the yogurts and a similar effect may have occurred with the puddings. In addition, the increase in viscosity could be due to an increase in soy protein content on food products (Schmidt et al., 1980). There are few studies that have shown the flavor characteristics of soy protein products. It is understood that components such as hydroperoxides presented in soybeans, when degraded, lead to the development of volatiles compounds that are responsible for the beany, grassy flavor of soy protein products (Liu, 1997).

Samples which contained 6% protein showed no significant differences in sweetness, with samples 3 (3%SPC/3%SPI), 5 (3%WPC/3%SPI), and 7 (3%WPC/3%SPC) having similar sweetness values (ranging from 6.4 to 6.7 on the 15cm line scale). From these results it is obvious that the type of protein added to the pudding does not have an effect on sweetness, since the samples have different proteins all added to the same level. However, significant differences were identified for chocolate, beany and grainy attributes.

No significant differences in chocolate flavor and beany attributes were detected in the chocolate puddings with 3% protein addition, such as samples 4 (3% WPC), 6 (3%SPC), and 8 (3% SPI). However, the samples did differ in sweetness with SPC sample (sample 6) being
perceived as significantly sweeter than the SPI sample (sample 8). The WPC sample (sample 4) and the SPC sample (sample 6) were also significantly grainier than the SPI sample (sample 8). The results imply that whey and soy protein concentrate affect flavor in a similar manner to SPI, but SPI have an effect on the texture and taste of the puddings. Sensory changes to ice creams caused by soy protein isolate have been investigated by others (Friedeck et al., 2003). Significant changes in flavor and texture were found in ice creams fortified with soy protein isolate compared to an unfortified sample. An increase of SPI caused a decrease in sweet taste, salty taste and cooked flavor. With regards to texture, the addition of SPI caused an increase mouth coating and chalkiness.

Although the products were made to have similar or matching viscosities readings, sensory perceptions showed that perceived thickness differed. The sample with no protein added (sample 1) was perceived to be thicker than the other samples. This differs to what others have observed. According to Childs et al., (2007), addition of whey and soy protein can contribute to increased thickness. One reason may be due to the fact that, when the puddings are consumed, they are warmed up in the mouth, mixed with saliva and then moved to the back of the mouth for swallowing. This process could be responsible for modifying how the texture of the puddings was perceived by the panelist. None of that happen with viscometer, which is essentially a round spindle moving through the pudding.
### Table 4-7: Effect of protein fortification on chocolate puddings sensory properties

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/0/0</td>
<td>13.8</td>
<td>1.04</td>
<td>13.9</td>
<td>0.62</td>
<td>0.6</td>
<td>0.41</td>
<td>0.49</td>
<td>1.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/3/3</td>
<td>3.5</td>
<td>2.71</td>
<td>2.3</td>
<td>1.72</td>
<td>12.7</td>
<td>1.60</td>
<td>13.0</td>
<td>1.32</td>
<td>10.5</td>
<td>2.02</td>
</tr>
<tr>
<td>0/3/3</td>
<td>6.4</td>
<td>2.41</td>
<td>6.7</td>
<td>2.80</td>
<td>9.5</td>
<td>2.14</td>
<td>9.5</td>
<td>1.88</td>
<td>9.3</td>
<td>1.83</td>
</tr>
<tr>
<td>3/0/0</td>
<td>8.9</td>
<td>3.55</td>
<td>10.2</td>
<td>2.71</td>
<td>4.7</td>
<td>2.78</td>
<td>4.9</td>
<td>2.59</td>
<td>8.2</td>
<td>3.12</td>
</tr>
<tr>
<td>3/0/3</td>
<td>6.7</td>
<td>3.20</td>
<td>4.7</td>
<td>2.33</td>
<td>11.0</td>
<td>1.82</td>
<td>10.6</td>
<td>2.05</td>
<td>9.1</td>
<td>2.01</td>
</tr>
<tr>
<td>0/3/0</td>
<td>10.1</td>
<td>2.28</td>
<td>9.4</td>
<td>2.21</td>
<td>4.7</td>
<td>2.22</td>
<td>4.0</td>
<td>1.98</td>
<td>2.5</td>
<td>2.00</td>
</tr>
<tr>
<td>3/3/0</td>
<td>6.7</td>
<td>2.89</td>
<td>8.3</td>
<td>2.65</td>
<td>7.8</td>
<td>2.68</td>
<td>9.3</td>
<td>1.85</td>
<td>7.9</td>
<td>2.17</td>
</tr>
<tr>
<td>0/0/3</td>
<td>7.4</td>
<td>2.97</td>
<td>10.1</td>
<td>2.11</td>
<td>4.2</td>
<td>2.61</td>
<td>2.9</td>
<td>1.28</td>
<td>3.8</td>
<td>2.74</td>
</tr>
</tbody>
</table>

1: numbers indicate % of whey protein concentrate/soy protein concentrate/soy protein isolate
2: n=12 judges x 4 reps= 48 evaluations
3: Means in a column with the same letter are not significantly different (p≥0.05)
4: All attributes evaluated on a 15 cm line scale, where: 0= low and 15=high

#### 4.5 Conclusion

The objective of this research was to develop and categorize the pudding formulations to understand the effect of protein addition on nutritional and sensory and properties of pudding. This objective was achieved by using and Taguchi $L_82^7$ experimental design to develop the
chocolate pudding formulations. Additionally, this objective was achieved by using instrumental analysis to evaluate macronutrients, moisture and viscosity content of the chocolate puddings; and also sensory evaluation (descriptive analysis) to characterize the chocolate puddings. As expected the protein content was higher for sample 2 (3% WPC/3%SPC/3%SPI) and lower for sample 1 (control/ no protein added). Significant differences of moisture and ash content of the samples were not found (Appendix D). Due to a small fat content on the puddings, the Soxhlet was not able to measure this macronutrient.

Moreover, through descriptive analysis was possible to detect specific sensory changes caused by protein fortification on the chocolate puddings. Fortification was associated it with decrease in sweetness and chocolate flavor, and increase in graininess and beany. Even though, this analysis showed how the sensory properties of the chocolate puddings were affected by fortification, consumer testing has to be completed in order to detect the impact of fortification on the liking. Results show that perceived thickness differed from each participant, due to the process of texture change when the puddings were eaten and swallowed.

Finally, it is also important to understand the impact of fortification on the sensory properties of the chocolate puddings by older adults.
CHAPTER 5- TO DETERMINE HOW THE SENSORY CHANGES IMPACT CONSUMER LIKING BY OLDER ADULTS

5.1 Introduction

Food fortification has been shown to be a good strategy to improve nutrient intake in older adults (Tsikritzi et al., 2014; 2015). However, in order to fortify foods to exert a positive effect on nutrient intake among older adult population, these foods need to be well accepted and liked. For this to happen, a proper evaluation of the sensory properties, as well as the consumer acceptance of these foods have to be examined.

As described in Chapter 4, fortification alters the sensory properties of the foods; however these changes may or may not affect the liking or acceptance of these foods. Despite sensory changes to biscuits fortified with micronutrient and whey protein, liking scores of the fortified biscuits did not differ from that of the unfortified biscuits (Tsikritzi et al., 2014). Older adults often experience significant changes in their sensory abilities as they age, meaning that some unpleasant flavors, such as an off taste may not be detected when consuming fortified foods (Tsikritzi et al., 2015). This may have contributed to the lack of differences in liking between a fortified and unfortified biscuit. Field (2016), however, has shown that liking of a soup is altered with the soup that was fortified with micronutrients. Liking was not consistent, with three groups observed; one group who showed increased liking with fortification, one group who showed decreased liking with fortification and one group with liking that did not change with fortification. Knowing that there may be differences in liking among the older adult population, consumer testing for liking must be conducted when a food is fortified. This will ensure consumption.
Often when conducting hedonic testing, it is desirable to understand factors that contribute to liking. For this Check-All-That-Apply (CATA) has recently been adopted (Scott, 2016). Scott (2016) showed that among different types of sensory test, CATA was the most appropriate test to be conducted with older adults. The CATA test provided valid results when they were compared between a group of younger and a group of older participants. The use of CATA when studying consumer liking with older adults has also been adopted by Field (2016). The results of this study showed that CATA was able to provide an understanding of the sensory attributes responsible for liking.

The fact that for many older adults it is a challenge to clearly discriminate food products based on their sensory properties, means that it is necessary to validate the use of CATA for understanding factors contributing to liking. In this research Preference Map (PREFMAP), where descriptive data from a trained panel is related to consumer liking were also developed to compare liking score from older adults’ intensity results from a trained panel. Pairing preference mapping results with the CATA-hedonic results will strengthen the understanding of sensory factors that contribute to liking of protein fortified pudding.

The objective of this research was to determine how the sensory changes caused by protein addition on the puddings impacted consumer liking by older adults. In order to better understand this impact, two types of tests were completed; CATA results collected from older adults and a PREFMAP using descriptive analysis results.
5.2 Materials & Methods

This research was divided into two steps. First, a napping session was carried out to understand the attributes that individuals use to describe pudding. These were then used to develop terminology for use during two steps of the studies, the consumer study using liking testing and CATA evaluations. The 8 chocolate pudding samples that were prepared according to the Taguchi experimental design describe in section 4.2.1 were also prepared for use in this study.

5.2.1 Napping

The napping test was conducted in the Sensory Evaluation Lab in the Food Science Department at the University of Guelph, in a one-hour session. Fifteen participants from the Department of Food Science were recruited to take part in this study. This number is within the range suggested by others when performing napping with consumers (Ares et al., 2010). Prior to starting the experiment, a consent form was given to each participant (Appendix E). A brief training was given prior to start the test, for clarification purposes. The participants were instructed to try the samples and place on the sheet of paper, placing the sample according to similarities and differences, and also putting some attributes to describe each sample.

For this session, blank sheets of paper, size 40cm x 60cm was provided as described in Pages (2003). The samples were presented simultaneously to all participants, and served in small plastic cups labeled with 3-digit random codes. Approximately 40g of each pudding was served to the participants. They were allowed to taste the samples in any order and as many time they needed to complete their evaluations. Sliced apples and water were provided to each participant to cleanse the palate between each sample.
Participants were instructed to taste the samples and place them on the sheet according to the similarities and dissimilarities of their sensory attributes. Similar samples were put close together, and different samples far apart. According to Pages (2003), a better evaluation of samples occurs when associating words with each sample to avoid the evaluation based on just one attribute. For this reason, the participants were asked to mark an “x” under each sample and list attributes that best described them.

5.2.2 Liking acceptance & Check-All-That-Apply (CATA)

To obtain an understanding of changes in liking resulting from fortification liking acceptance testing and CATA were conducted. A total of 61 healthy older adults (male=21; female=40), aged 60+ years old were recruited from the City of Guelph (n=40) and from the City of Waterloo (n=21). For recruitment of participants, posters were placed in grocery stores, community centers and libraries.

Both CATA and liking acceptance were performed simultaneously. The study was held in two different locations. In Waterloo the study was held at the Research Institute of Aging (RIA), in the cafeteria area, where each participant had a separate table to perform the test; in Guelph the study was held at the Department of Food Science, University of Guelph, in the sensory booths. Prior to starting the experiment a consent form (REB # 15NV038) and information form with details about the test and the ingredients used were given to each participant (Appendix F). Participants were also asked to complete a screening questionnaire to verify if they were suitable to participate of the study. To be part of the study, participants could
not have any allergies to the ingredients used in the study. Aside from the testing locations, the study was conducted in the same manner.

The samples were randomly assigned with a 3-digit code and given one at the time to each participant. Approximately, forty grams of the pudding was put into plastic cups and served at room temperature (around 25°C). Water and sliced apples were given to the participants to clean the palates between each sample. The participants received a questionnaire, where contained the CATA and liking acceptance questions for each sample in their respective attributes (Appendix G).

Participants were asked to first, indicate how much they liked the samples from a flavor, texture, appearance and overall liking perspective, using the 9 point hedonic liking scale that ranged from 1 (‘Dislike Extremely’) to 9 (‘Like Extremely’) . Following each liking question, A CATA scale was provided so that participants could check all of the attributes was also asked. For the CATA test, the older adults were instructed to check on the list all the attributes that they thought was more appropriate to describe the samples. More than one attribute could be checked, and there was not wrong or right answers. The attributes included in the CATA list were selected based on the Napping and trained panel results.
5.3 Statistical Analysis

5.3.1 Napping

The data collected from this test was created by measuring the X and Y coordinates, from the left bottom corner of the sheet, for each judge. This information was recorded on a spreadsheet for each sample. On the same sheet, the attributes given for each sample were collected, and were treated as supplementary variables during the analysis. When attributes with same meaning were given, they were combined (i.e. gooey/sticky; shiny/glossy). If the meaning was unclear, they were kept separate. Attributes that were cited by just one participant were not included in the analysis.

A Multiple Factor Analysis (MFA) was used to analyze the recorded napping data. The X and Y coordinates generated from each judge were treated as un-standardized variables. The table containing the consumer’s descriptors was treated as supplementary variables, which means that they had low weight in the constructions of the axes. Both the correlation coefficient and the MFA factors were calculated and displayed onto a project map. The analysis was completed using XLSTAT Version 2014.4.09 (Addinsoft 1995-2014 ©).

5.3.2 Liking Acceptance & Check-All-That-Apply (CATA)

An Analysis of Variance (ANOVA) was used for the liking acceptance data in order to verify if there was difference in liking among the samples, adopting a 95% confidence level for all the attributes evaluated. A posthoc analysis was conducted through Tukey’s Honestly Significant Difference (HSD) test to determine where significant difference existed among sample means.
Afterward, CATA and hedonic overall liking scores were analyzed by penalty analysis to determine the mean impact of each attribute on overall liking.

For the CATA test, the frequency of each attribute was established by counting the number of participants that used that attribute to evaluate the pudding samples. A contingency table was created with terms used to describe the chocolate puddings, and the number of mentions of the terms. A Cochran’s Q test, which is used in the analysis of nominal data, was used to identify significant differences among the samples for each attribute. Correspondence analysis (CA) was conducted on the contingency table and the first two dimensions were plotted to obtain the sample and attribute configurations for each group. The overall liking scores were treated as supplementary variables to verify what attributes were responsible for liking.

A comparison between the results from the trained panel data collected in Chapter 4 (reported in section 4.4.2) and the older adult liking acceptance was also conducted through a PREFMAP. This was obtained by running a Principal Component Analysis (PCA) as the first step. Due to the diversity of the population, participants were clustered based on their overall liking, so the results would be easier to interpret. Agglomerative Hierarchical Cluster Analysis (AHC) was carried out using the Ward’s method.

All data was analyzed using XLSTAT Version 2014.4.09 (Addinsoft 1995-2014 ©).

5.4. Results and Discussion

5.4.1 Napping

The product map generated from the napping results for the 8 chocolate puddings is shown in Figure 5-1. The first two factors explained 51.07% of the variation between the samples. As
shown on the map, participants grouped the samples based on the amount of protein used, rather than the type. Sample 1 (0% protein) was grouped separated from the others, as well as the sample containing all three proteins (sample 2 (3% WPC/3% SPC/3% SPI)). The attributes given to describe the samples were also very different. For example, attributes such as high smooth, high chocolate, high milky and not grainy was used to describe the sample with no protein added (sample 1); and low sweet, low chocolate and high grainy appeared for sample with the highest amount of protein added (sample 2). The samples containing only one type of protein (sample 4 with 3% WPC, sample 6 with 3% SPC and sample 8 with 3% SPI) were all grouped very close and had similar attributes to describe them, such as medium sweet, medium chocolate, low grainy. The samples that contained 2 types of protein (sample 3 with 3% SPC/3% SPI, sample 5 with 3% WPC/3% SPI and sample 7 with 3% WPC/3% SPC) were associated with attributes such as medium taste, high after taste, grainy. This study shows that amount rather than the type of protein was responsible for the sensory differences among the samples.
Figure 5-1: Biplot representation of the eight chocolate puddings and consumers’ descriptions on the first two dimensions of MFA and considering descriptors as supplementary variables.

Foot note:
- 1 (sample 1): 0% protein; 2 (sample 2): 3% WPC/3% SPC/3% SPI; 3 (sample 3): 3% SPC/3% SPI; 4 (sample 4): 3% WPC; 5 (sample 5): 3% WPC/3% SPI; 6 (sample 6): 3% SPC; 7 (sample 7): 3% WPC/3% SPC; and 8 (sample 8): 3% SPI.
The napping results from this study indicate that the addition of proteins (SPC, SPI, and WPC) changed the sensory properties of the chocolate puddings and how samples were grouped, based on the level of fortification, rather of the type of protein utilized. Furthermore, the sensory attributes generated by napping suggested that the sensory differences was seeing in all sensory modalities- color, flavor/taste and texture; and also that as the protein amount increases, texture are described as grainy, thick, and colors become lighter in comparison to the lower protein amounts. As for flavor/taste, the sweetness and chocolate decreased with the increase of protein.

5.4.2 Liking Acceptance & Check-All-That-Apply (CATA)

5.4.2.1 Liking Acceptance

ANOVA results revealed that there were significant fortification effects on overall liking, liking of appearance, flavor and texture (Appendix H). Means for the hedonic assessments are presented in Table 5-1. Fortification had very little impact on hedonic scores for liking of appearance. Overall liking, liking of flavor and texture scores were higher for samples with lower percentage of protein, such as sample 1 (0%), 4 (3% WPC), 6 (3%SPC) and 8 (3%SPI). The mean hedonic scores varied between 6 and 7, which translate to liking slightly and liking moderately, respectively.

Samples with higher percentage of protein had lower scores on overall liking, liking of flavor and texture, such as sample 3 (3%SPC/3%SPI) 5 (3%WPC/3%SPI), 7 (3%WPC/3%SPC), with hedonic score around 5. This translates to either like or dislike. Sample 2, which contained the highest amount of protein with 3%WPC/3%SPC/3%SPI, had the lowest score on overall liking, liking of flavor and texture, with mean score of approximately 4, translating to “dislike
slightly”. This suggested that when protein level increased, it exerted a significantly impact on liking.

**Table 5-1: Mean liking scores for appearance, flavor, texture and overall liking**

<table>
<thead>
<tr>
<th>Sample 1</th>
<th>Liking of appearance</th>
<th>Liking of flavor</th>
<th>Liking of texture</th>
<th>Overall liking</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0% protein)</td>
<td>Mean: 7.1&lt;sup&gt;1,2,a&lt;/sup&gt;</td>
<td>6.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.6&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>SD: 1.12</td>
<td>1.69</td>
<td>1.48</td>
<td>1.78</td>
</tr>
<tr>
<td>Sample 2</td>
<td>Mean: 5.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.8&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>(3%WPC/3%SPC/3%SPI)</td>
<td>SD: 1.8</td>
<td>1.82</td>
<td>1.82</td>
<td>1.64</td>
</tr>
<tr>
<td>Sample 3</td>
<td>Mean: 6.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>(3%SPC/3%SPI)</td>
<td>SD: 1.54</td>
<td>1.98</td>
<td>2.05</td>
<td>2.06</td>
</tr>
<tr>
<td>Sample 4</td>
<td>Mean: 6.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.3&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>(3%WPC)</td>
<td>SD: 1.34</td>
<td>1.78</td>
<td>1.47</td>
<td>1.77</td>
</tr>
<tr>
<td>Sample 5</td>
<td>Mean: 5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.8&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.2&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>4.6&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>(3%WPC/3%SPI)</td>
<td>SD: 1.78</td>
<td>1.90</td>
<td>1.72</td>
<td>1.78</td>
</tr>
<tr>
<td>Sample 6</td>
<td>Mean: 6.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.2&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>(3%SPC)</td>
<td>SD: 1.52</td>
<td>1.48</td>
<td>1.35</td>
<td>1.52</td>
</tr>
<tr>
<td>Sample 7</td>
<td>Mean: 6.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.5&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.4&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.5&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>(3%WPC/3%SPC)</td>
<td>SD: 1.89</td>
<td>1.8</td>
<td>1.99</td>
<td>1.89</td>
</tr>
<tr>
<td>Sample 8</td>
<td>Mean: 7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.4&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>(3%SPI)</td>
<td>SD: 1.54</td>
<td>1.61</td>
<td>1.33</td>
<td>1.54</td>
</tr>
</tbody>
</table>

**Foot note:**

- <sup>1</sup>: n= 61
- <sup>2</sup>: Data input on 9-point hedonic scale where 1 = dislike extremely; 5 = neither like or dislike, and 9 = like extremely.
- <sup>3</sup>: Means in a column with the same letter are not significantly different (p≥0.05)
Using the overall liking scores for all samples data, participants were clustered through the Agglomerative Hierarchical Cluster Analysis (AHC) using the Ward’s method. Clustering was completed in order to identify differences in liking among the participants. This resulted in 4 clusters of older adults that responded differently to fortification. Average liking scores for each group are shown in Figure 5-2. For the first consumer group (n= 18), liking decreased with an increase in protein amount. Group 2 individuals (n= 8) liked the control (i.e. no protein), samples 3 (6% protein addition) and 4 (3% protein addition), and the other samples presented a lower liking score. Group 3 (n=14) showed low liking scores for the control sample and the sample with all three proteins (sample 2), but higher liking for the samples that had one type of protein added (3% protein addition), such as sample 4, 6 and 8. Last, group 4 (n=21) showed no clear trend for liking, with slightly higher scores for the samples with no protein than for samples with protein added (Figure 5-2).
Participants were grouped using AHC (Ward’s method), based on their overall liking scores for each of the eight samples. Liking was rated on a 9-point hedonic scale, ranging from ‘Dislike Extremely’ (1) at one end to ‘Like Extremely’ (9) at the other.

### 5.4.2.2 Check-All-That-Apply (CATA)

When completing the CATA test, the older adults checked between 1 to 6 terms to describe the chocolate puddings. The attributes and the numbers of times they were mentioned are presented in Table 5-2. The most frequently mentioned terms used to describe the puddings were smooth texture, smooth appearance, medium brown, medium sweet, and medium chocolate; and the least mentioned were watery, thin, running and soft.

Correspondence Analysis (CA) was conducted on CATA counts, considering overall liking as supplementary variables. The first two dimensions on the map explained 84.46% of the experimental data variability, representing 65.81% and 18.65%, respectively (Figure 5-2).
shown in Figure 5-3 the first dimension of CA was positively associated with the attributes low sweet, powdery, grainy, off flavor, low chocolate, and negatively associated with the attributes very sweet, smooth appearance and medium sweet. All those attributes were more cited to describe the chocolate puddings, explaining their association with the first dimension, which explains the most part of the variability. In contrast, the second dimension was not positively associated with any attributes, while negatively associated with attributes runny and thin (more viscosity type of terms).

Figure 5-3 shows the samples were arranged into 4 main groups on the first and second dimensions. Sample 2 (3%WPC/3%SPC/3%SPI) and 5 (3%WPC/3%SPI), which were located at the first and fourth quadrant, respectively, corresponded to samples described as powdery, grainy, low sweet and off-flavor. The other samples, such as 1 (0% protein), 4 (3%WPC), 3 (3%SPC/3%SPI), 7 (3%WPC/3%SPC), located on the second quadrant were described as thick, dark brown and medium chocolate. The last group, which includes sample 8 (3%SPI) and 6 (3%SPC), located on third quadrant, were described as smooth, medium brown and medium sweet.

Sample 3 and 7, which were well differentiated by napping participants, were not separated by the older adults based on the CATA terms (Figures 5-1 and 5-3). The reasons could be due that CATA words were prescribed to participants based on the napping results, where participants could use whatever words they wanted, and did not allow for good product differentiation. During CATA, the older adults had the option of adding any other attributes they thought would be suitable to describe the samples. However, finding the right words for product differentiation may have been a challenge for them. Moreover, the age of participants may also have an impact on how they evaluated the samples. Recently, studies comparing sensory
evaluation between younger and older adults, shows that younger adults are better in discriminating food products (Scott, 2016; Field, 2016). This may be because of a decrease in sensory perception, commonly observed among older adults (Methven et al., 2015).

Table 5-2: Terms and number of mentions used by consumers to describe the chocolate puddings

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of mentions</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth texture</td>
<td>297</td>
<td>60.86</td>
</tr>
<tr>
<td>Smooth appearance</td>
<td>266</td>
<td>54.51</td>
</tr>
<tr>
<td>Medium brown</td>
<td>261</td>
<td>53.48</td>
</tr>
<tr>
<td>Medium sweet</td>
<td>222</td>
<td>45.49</td>
</tr>
<tr>
<td>Medium chocolate</td>
<td>198</td>
<td>40.57</td>
</tr>
<tr>
<td>Thick</td>
<td>183</td>
<td>37.50</td>
</tr>
<tr>
<td>Grainy</td>
<td>144</td>
<td>29.51</td>
</tr>
<tr>
<td>Low chocolate</td>
<td>141</td>
<td>28.89</td>
</tr>
<tr>
<td>Dark brown</td>
<td>132</td>
<td>27.05</td>
</tr>
<tr>
<td>Low sweet</td>
<td>101</td>
<td>20.70</td>
</tr>
<tr>
<td>Powdery</td>
<td>95</td>
<td>19.47</td>
</tr>
<tr>
<td>Light brown</td>
<td>89</td>
<td>18.24</td>
</tr>
<tr>
<td>High chocolate</td>
<td>85</td>
<td>17.42</td>
</tr>
<tr>
<td>Off-flavor</td>
<td>82</td>
<td>16.8</td>
</tr>
<tr>
<td>Very sweet</td>
<td>76</td>
<td>15.57</td>
</tr>
<tr>
<td>Bitter</td>
<td>40</td>
<td>8.2</td>
</tr>
<tr>
<td>Other (glossy/shinny)</td>
<td>34</td>
<td>6.97</td>
</tr>
<tr>
<td>Other (watery)</td>
<td>22</td>
<td>4.51</td>
</tr>
<tr>
<td>Other (thin)</td>
<td>18</td>
<td>3.69</td>
</tr>
<tr>
<td>Other (runny)</td>
<td>8</td>
<td>1.64</td>
</tr>
<tr>
<td>Other (soft)</td>
<td>2</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Foot note

n= 8 chocolate puddings
Figure 5-3: Biplot representation of the eight chocolate puddings and consumers’ descriptions on the first two dimensions of CA

When the principal coordinates analysis was completed to overlay liking scores onto the product map, overall liking was positively associated with the attributes dark brown, medium chocolate and thick, and negatively associated with the attributes low sweet, thin, off-flavor and powdery (Figure 5-4). This indicates that consumers prefer a dark brown, thick and moderate chocolate pudding, similar to what was observed in samples 6, 8 and possibly 1.
To further investigate how much the presence of each attribute selected using CATA affected liking, a penalty analysis was conducted. Penalty analysis is “a method used in sensory data analysis to identify potential directions for the improvement of products, on the basis of surveys performed on consumers or experts” (XLSTAT, 2017). Results show how much the influential attributes positively or negatively impact liking. As shown on Figure 5-5, the attributes smooth texture, medium chocolate, dark brown, smooth appearance, medium sweet,
thick and medium brown had a positive effect on liking, i.e. smooth texture increased the liking by 1.7 points on the 9-point hedonic scale. The attributes low sweet, grainy and low chocolate had a negative impact on liking (i.e. low chocolate decrease linking by 1.6 points on the 9-point hedonic scale). This means that samples 2 and 5, which were described as being grainy and low in chocolate flavor would be given a lower liking score than a sample that displayed more positive characteristics.

**Figure 5-5: Penalty Analysis CATA attributes/liking**

![Penalty Analysis CATA attributes/liking](image)

5.4.3. Preference Map (PREFMAP)

While the maps generated from the consumer data provide an understanding of attributes that contribute to liking, a Preference Map (PREFMAP), which plots liking against trained panel data, provides an understanding of how the contribution of an intensity of an attribute to liking.
To do this, a Principal Component Analysis (PCA) was first conducted on the sensory attributes evaluated by the trained panel. This provides a two-dimensional product map that explains the relationship between products and their descriptors (Figure 5-6). Products close together are significant positively correlated (similar characteristics). Samples 3, 5, 7 and 2 are associated with the attributes grainy and beany; samples 1 and 4 with attributes sweet and chocolate; and samples 6 and 8 fall on the opposite end of the dimension, which is associated with thickness. These results were similar to the napping results, regarding to the sample grouping and the attributes used to describe the samples. For example, in napping there were 4 groupings (group 1= sample 1, containing no protein; group 2= sample 2, containing 9% protein; group 3= sample 3, 5, and 7, with 6% protein; and group 4= sample 4, 6, and 8 with 3% protein). Attribute such as chocolate was used to describe sample 1, grainy was used to describe sample 2, 3, 5 and 7; and low grainy was used to describe sample 4, 6, and 8.

CATA results, however, showed different sample grouping in comparison to napping. The reason might be due to the consumers’ age, younger individuals are better in discriminating food products. For example, sample 1 was grouped with sample 3, 7 and 4. Attributes such as thick, bitter and medium brown were used to describe these samples. In all of the three tests (PREFMAP, Napping and CATA) sample 2 was describe as having low sweetness, off-flavor/beany and high graininess.
The data from the PCA and AHC (from section 6.4.2.1) were then used to generate a PREFMAP. Supplementary tables of data used to complete the PREFMAP are found in Appendix J.

Looking at both preference map and the correlation circle of the PCA (Figure 5-7(a) and Figure 5-7 (b)), it is possible to observe that the consumers of cluster 1 like the chocolate puddings that are sweet and chocolate, and dislike chocolate puddings that are grainy and beany, while consumers of cluster 2 like puddings that are sweet, chocolate and thick. Consumers of cluster 3 like the chocolate puddings that are either grainy or thick, and like a little sweet and chocolate, which is typical of sample 4, 6, and 8. The attributes that drive liking is a little uncertain for consumers of cluster 4, but it seems that all attributes were contributing for liking (average in all criteria).
The results showed that no consumers liked puddings with an amount of protein higher than 6%, which is the case of sample 2, 3, 5 and 7. Different attributes affect liking, for instance people from group 1 liked puddings that were sweet, chocolate and of group 2 liked the puddings that were sweet, chocolate and thick. For consumers of group 3, the attributes did not have much effect on liking, and last, group 4 liked the puddings that presented an average of all the attributes. Puddings with 3% protein addition or less were the most liked, such as samples 1, 4, 6 and 8.
5.5. Conclusion

The objective of this research was to determine how the sensory changes caused by soy and whey protein addition impacted consumer liking by older adults. Napping results showed that the consumer panel grouped the samples according to the amount of protein added rather than the type. A total of 4 groups were created: group 1= sample 1 (0 protein), group 2= sample 2 (3% WPC/3%SPC/3%SPI), group 3= sample 3 (3%SPC/3%SPI), sample 5 (3% WPC/3%SPI), sample 7 (3% WPC/3%SPC), and group 4= sample 4 (3%WPC), sample 6 (3%SPC) and sample 8 (3%SPI). An increase amount of protein resulted in chocolate puddings with higher rates of graininess and off-flavor, and lower rates of sweetness and chocolate flavor.

Overall, liking of the chocolate pudding was affected by protein fortification. Liking of appearance was the only hedonic score that did not have a big impact on liking caused by protein fortification. An increase in protein into the chocolate puddings resulted in decreasing of liking. Furthermore, the results from CATA showed that overall liking was positively associated with the attributes dark brown, medium chocolate and thick. Older adults could not differentiate the samples very well when compared with the napping participants. For that reason, a preference map was carried out in order to better understand the attributes that were responsible for liking. The preference map generated from the PCA and clustering allowed the conclusion that chocolate puddings with 6% or higher of protein addition, resulted in decreasing of liking. Attributes such as grainy and beany decreased liking; sweet, chocolate and thick increased liking. Although liking scores were reasonable, they were lowest for samples which showed attributes of grainy and beany, such as sample 2, 3, and 5.
CHAPTER 6: CONCLUSIONS AND FUTURE DIRECTIONS

The objectives of this research were to develop chocolate pudding formulations with different protein content, as well as to categorize these puddings to understand the effect of protein addition on the nutritional and sensory properties on this food. Moreover, the impact on consumer liking due to the sensory changes caused by protein addition was also examined. A few studies have evaluated the impact of both whey and soy protein addition on foods, mainly targeting older adult population. This work is the first one to investigate the effect of both soy and whey protein on the sensory properties and liking of chocolate puddings by older adults. The 8 chocolate puddings were formulated following the L_8^{2^7} Taguchi design. Instrumental analysis was carried to investigate viscosity, protein, fat, moisture, ash and carbohydrate of all the puddings. Protein content determined by instrumental analysis was compared to that calculated using the Canadian Food Inspection Agency (CFIA) health claims formula. Furthermore, descriptive analysis was used to quantify sensory changes due to protein fortification. Then, a rapid profiling method known as napping was complete with younger consumers to determine the overall impact of fortification on the sensory properties of the puddings. Last, consumer testing was complete to determine the acceptance of the puddings to older adults, and Check-All-That-Apply (CATA). Also, the hedonic scores of older adults were associated with the descriptive analysis data in order to fully understand the attributes responsible for liking.

The puddings with 2 or more types of protein added to it, reached or exceeded the Protein Ratio (PR) of 20, and could carry a health claim of “more protein” according to CFIA. When puddings with an amount of protein greater than 9% were tested, they presented unpleasant sensory attributes. Moreover, a number of sensory differences were identified on the chocolate puddings due to the protein addition. An increase on protein content caused a decrease in sweet
and chocolate flavor, and an increase on beany and graininess. Previous work has also identified sensory changes caused by protein fortification. Addition of soy protein into yogurt was responsible for a decrease in sweetness, and increase in beany flavor and chalkiness (Drake et al., 2000). However, more studies have to be conducted using both whey and soy in other types of food, since the effect of this protein is different for each type of food.

As the napping results showed, the grouping of the chocolate puddings was based on the amount of protein rather than the type. Grainy, off-flavor, low sweetness, low chocolate, light brown were some of the attributes used to describe the puddings with high percentage of protein. This agrees with other studies that have shown that foods fortified with whey and soy proteins tend to have after taste/off-flavor (Childs et al., 2007). Attributes such as after taste, off-flavor, grainy, bitter are common attributes found in whey fortified products (Desai et al., 2013). A lower percentage of protein led to attributes such as medium sweet, high chocolate, dark brown, smooth being used to describe the puddings.

The liking acceptance, as well as the product profiling of the chocolate puddings were completed using 9 point hedonic scale and CATA, respectively. Protein addition into the chocolate puddings had a significant impact on liking of flavors, tastes and textures. Liking of appearance was the only hedonic score not greatly impacted by protein addition. The CATA results indicated that differences in liking were more associated to flavor and texture perception. Furthermore, the overall liking was positively associated with attributes dark brown, medium chocolate and thick, and negatively associated with the attributes low sweet, thin, off-flavor and powdery. These results are similar to those observed by Ares et al. (2010), who found that chocolate flavor and thickness were responsible for increasing overall liking. This will be very important when formulating the puddings, because greater amounts of whey and soy protein
might create undesirable flavors. Older adults were not able to discriminate well the chocolate puddings when compared to Napping using younger consumers.

The CATA results are similar to what was observed from the preference mapping analysis. Puddings with 6% or greater of protein resulted in decreasing of liking. Attributes such as grainy and beany were responsible for decreasing liking, and moderate chocolate and sweet flavor, as well as a thick texture was responsible for increasing liking, which seems the attributes that drive liking was the same as CATA, but the grouping was different. Limited work has been done evaluating the impact of protein fortification of foods on liking, especially with older adults. Also, even less work has been completed looking at association between liking using older consumers and descriptive analysis data in order to better understand the attributes responsible for liking.

It should be noted that, within the research, the older adults were not able to discriminate the chocolate puddings as well as the younger consumers when the CATA data was compared to napping data. Individual variability among older adults due to for example, dentition and oral health has been demonstrated (Quandt et al., 2010) are some of the problems that make sensory evaluation more challenging for this population. It is necessary, however, to test using this population as they are the demographic for which the product is designed.

Future directions

This research has presented detailed information about the nutritional and sensory properties of the chocolate puddings, and their liking/acceptance to older adults. The development of the fortified pudding formulations with acceptable sensory properties, from a flavor and texture perspective, could stimulate older adults’ food intake, and therefore, increase
the amount of protein consumed by this population. Fortifying foods using whey and soy protein would be very helpful in combating protein deficiency. These proteins are both considered high quality proteins that goes beyond stimulating muscle protein synthesis (MPS). A clinical study would be very valuable to be conducted with older adults, in order to know if the amount of protein added to the puddings that were liked, would exert any effect on their nutritional status, in regards to improve malnutrition.

The formulations developed for this study could be very valuable for future use in Long Term Care Institutions (LTC), since malnutrition for protein deficiency is commonly seen in older adult population. Furthermore, the outcomes of this study could also have an impact on the food industry. The high demand for health food alternatives makes this fortified puddings a great choice for being developed in high scales by the food industry. The same methodology could be used for this study to develop the puddings could be used in other similar studies and in other food products. Sensory changes due to protein fortification differ from food to food, and so it is very important to evaluate both sensory properties and liking of each food being fortified.

For this study, the increase of protein on the chocolate puddings resulted in decrease of liking. Pudding fortified with 3% or 0% of protein had the highest liking. Puddings with 6% of protein or higher were not well accepted by older adults. Although those samples did not meet the PR of 20, still they would increase the protein content consumed by this population. The results showed that fortification using protein is still very challenging due to changes in the sensory properties, resulting in increase of beany and grainy, and decrease in sweetness, for example.
Finally, many opportunities exist to investigate the addition of protein into foods. More studies should be done to evaluate the impact of soy and whey fortification on other food products, besides pudding. Furthermore, the food industry should look into a greater variety of protein-enriched food, not only focused towards older adult population, but also for all age groups.
CHAPTER 7: REFERENCES CITED


Federation of Canadian Municipalities. (2013). Canada’s aging population: The municipal role in Canada’s demographic shift. Ottawa, ON.

Field, Katherine (2016). Micronutrient Fortification for Older Adults in Long-Term Care: Sensory Consideration. University of Guelph.


Lum, J. et al. (2010). Balancing Care for Supportive Housing: Final Report (Toronto, Ont.: University of Toronto).


Scott, N., 2016. Exploring the use of Rapid Profiling Techniques in Older Adult Sensory Testing. MSc Thesis, University of Guelph


## APPENDIX A: PR Calculation

<table>
<thead>
<tr>
<th></th>
<th>WPC</th>
<th>SPC</th>
<th>SPI</th>
<th>Milk</th>
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<th>WPC</th>
<th>SPC</th>
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<td>3.9</td>
<td>0</td>
<td>98.8</td>
</tr>
</tbody>
</table>

Calculation:

PR= Protein in a Reasonable Daily Intake (PRDI) x Protein Efficiency Ratio (PER), where PRDI = percent (%) protein in the food x reasonable daily intake of the food

Reasonable daily intake of puddings= 130g. CFIA recommends= 80-140g

<table>
<thead>
<tr>
<th>Protein</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried whey</td>
<td>2.6</td>
</tr>
<tr>
<td>Soy protein</td>
<td>2</td>
</tr>
<tr>
<td>Milk</td>
<td>2.5</td>
</tr>
</tbody>
</table>

PR sample 1= \((0\times0.8\times2.6) + (0\times0.764\times2) + (0\times0.9\times2) + (105.95\times0.036\times2.5)\) = 10

PR sample 2 = \((3.9\times0.8\times2.6) + (3.9\times0.764\times2) + (3.9\times0.9\times2) + (105.95\times0.036\times2.5)\) = 30

PR sample 3 = \((0\times0.8\times2.6) + (3.9\times0.764\times2) + (3.9\times0.9\times2) + (105.95\times0.036\times2.5)\) = 21

PR sample 4 = \((3.9\times0.8\times2.6) + (0\times0.764\times2) + (0\times0.9\times2) + (105.95\times0.036\times2.5)\) = 17

PR sample 5 = \((3.9\times0.8\times2.6) + (0\times0.764\times2) + (3.9\times0.9\times2) + (105.95\times0.036\times2.5)\) = 24

PR sample 6= \((3.9\times0.8\times2.6) + (3.9\times0.764\times2) + (0\times0.9\times2) + (105.95\times0.036\times2.5)\) = 15

PR sample 7 = \((3.9\times0.8\times2.6) + (3.9\times0.764\times2) + (0\times0.9\times2) + (105.95\times0.036\times2.5)\) = 23

PR sample 8 = \((0\times0.8\times2.6) + (0\times0.764\times2.5) + (3.9\times0.9\times2) + (105.95\times0.036\times2.5)\) = 16
## APPENDIX B: Viscosity Calculation

<table>
<thead>
<tr>
<th>Samples</th>
<th>Viscometer Reading (cP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (0% Protein)</td>
<td>13,435±2689.83</td>
</tr>
<tr>
<td>2 (3% WPC/3% SPC/3% SPI)</td>
<td>10,783.5±1437.55</td>
</tr>
<tr>
<td>3 (3% SPC/3% SPI)</td>
<td>12,300±2167.99</td>
</tr>
<tr>
<td>4 (3% WPC)</td>
<td>12,150±2333.45</td>
</tr>
<tr>
<td>5 (3% WPC/3% SPI)</td>
<td>10,700±848.53</td>
</tr>
<tr>
<td>6 (3% SPC)</td>
<td>10,483±3181.98</td>
</tr>
<tr>
<td>7 (3% WPC/3% SPC)</td>
<td>12,916.5±871.86</td>
</tr>
<tr>
<td>8 (3% SPI)</td>
<td>10,450±70.71</td>
</tr>
</tbody>
</table>
APPENDIX C: Consent form trained panel

Department of Food Science
50 Stone Road E, Building 038
Guelph, ON N1G 2W1

CONSENT TO PARTICIPATE IN RESEARCH

Sensory Evaluation of Chocolate Puddings

You are asked to participate in a research study conducted by Lisa Duizer and Thais Honsberger. If you have any questions or concerns about the research, please feel free to contact

Lisa Duizer: Faculty member in the Department of Food Science

Phone: 519-824-4120 ext 53410.
E-mail: lduizer@uoguelph.ca

Thais Honsberger: MSc student researcher in the Department of Food Science
E-mail: tcastro@uoguelph.ca

PURPOSE OF THE STUDY

To determine the sensory differences present in chocolate pudding formulations

In this study, you will be eating puddings which contain the following ingredients:

- Starch, unsweetened cocoa, sugar, vanilla extract, whey protein concentrate, soy protein concentrate, soy protein isolate and milk

You will also be cleansing your palate with apple and water.

If you know that any of these products/ingredients are likely to cause you discomfort or you are allergic to them, please do not take part in this study.
PROCEDURE

Once we have determined that you will not suffer any adverse effects from eating the food products, you will start the training sessions:

You will be trained to evaluate the intensity of sensory attributes of chocolate puddings.

The training process is expected to take 10-15 sessions of approximately one hour. These sessions will be held five days per week (Monday-Friday). The time for the sessions will be confirmed with you after screening has taken place.

Training involves meeting as a group to taste and describe the tastes/flavors of various pudding samples. We will work with you to define those descriptors and then teach you how to evaluate various puddings types for those descriptors. The final stages of the training involve you practicing making your evaluations in a sensory booth using a computer to input your responses.

During each training day you will be provided with an ingredient list of the food products that you will taste. Please let us know if you are allergic to any of the ingredients or if you feel uncomfortable eating any of the products. You will not receive a large amount of any of the food products but if you feel that you are getting full, you can stop eating at any point during training.

Testing:

After you have been trained, you will be asked to evaluate products for the characteristics in which you were trained using a computer for data entry.

The panelists will be contacted by e-mail to invite them for a follow-up session to review the aggregate results.

POTENTIAL RISKS AND DISCOMFORTS

It is not anticipated that you will suffer any adverse reactions to consuming these foods. The quantities served to are all smaller than you would eat under normal situations. You do not have to eat the entire sample presented to you. You have to eat enough to make an evaluation.

There is a standard risk of choking associated with eating any food. This risk will not be any higher than what is encountered in everyday life. There is a risk of allergic reaction and discomfort for individuals with allergies and/or sensitivities to any of the ingredients present in these foods. To prevent any adverse reactions, you have been provided with a list of ingredients and asked to complete a questionnaire regarding any food allergies and/or sensitivities that you may have.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

The information collected will help with the development of nutritionally enhances food products with acceptable sensory attributes.

PAYMENT FOR PARTICIPATION
We will reimburse you $15.00 for each testing and training session that you attend. If you cannot make a tasting session, please contact us to let us know. The SIN number might be requested by the research team and the University financial services for payment purposes.

CONFIDENTIALITY

Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study.

After the data has been collected, only the student and faculty members involved with the project will have access to the anything which identifies you. At no time will individual identifiers be released. All data will be averaged and standard deviations will be calculated.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. Participants will have the right to remove their data from the project. There will be no consequences for doing so.

PROJECT SPONSOR

Omafra: University of Guelph partnership program

RIGHTS OF RESEARCH PARTICIPANTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. This study has been reviewed and received ethics clearance through the University of Guelph Research Ethics Board. If you have questions regarding your rights as a research participant, contact:

Director, Research Ethics
University of Guelph
437 University Centre
Guelph, ON N1G 2W1

Telephone: (519) 824-4120, ext. 56606
E-mail: sauld@uoguelph.ca
Fax: (519) 821-5236
SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I have read the information provided for the study “Sensory Evaluation of Chocolate Puddings” as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____________________________________
Name of Participant (please print)

____________________________________
Signature of Participant

Date

SIGNATURE OF WITNESS

____________________________________
Name of Witness (please print)

____________________________________
Signature of Witness

Date

[The witness is ideally NOT the investigator, but if there is no readily available alternative, the investigator can act as witness.]
## APPENDIX D: ANOVA Proximate Analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture (%) Mean</th>
<th>Protein (g/100g) Mean</th>
<th>Carbohydrate (g/100g) Mean</th>
<th>Ash (g/100g) Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>62.66&lt;sup&gt;1,2,a&lt;/sup&gt;</td>
<td>5.25&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.04&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
<td>0.25</td>
<td>0.02</td>
<td>0.28</td>
<td>0.01</td>
</tr>
<tr>
<td>Sample 2</td>
<td>62.67&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>10.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.76&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.05&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
<td>1.15</td>
<td>0.07</td>
<td>1.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Sample 3</td>
<td>62.27&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>8.46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.05&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
<td>1.51</td>
<td>0.07</td>
<td>1.55</td>
<td>0.03</td>
</tr>
<tr>
<td>Sample 4</td>
<td>60.33&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.6&lt;sup&gt;d&lt;/sup&gt;</td>
<td>33.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.03&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
<td>1.27</td>
<td>0.03</td>
<td>1.24</td>
<td>0</td>
</tr>
<tr>
<td>Sample 5</td>
<td>61.2&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>8.44&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>30.32&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.05&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
<td>1.87</td>
<td>0.01</td>
<td>1.84</td>
<td>0.02</td>
</tr>
<tr>
<td>Sample 6</td>
<td>64.02&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.59&lt;sup&gt;c&lt;/sup&gt;</td>
<td>30.37&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.03&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
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<td>0.08</td>
<td>0.71</td>
<td>0</td>
</tr>
<tr>
<td>Sample 7</td>
<td>62.67&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>8.09&lt;sup&gt;c&lt;/sup&gt;</td>
<td>29.2&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>0.05&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
<td>1.46</td>
<td>0.21</td>
<td>1.22</td>
<td>0.03</td>
</tr>
<tr>
<td>Sample 8</td>
<td>65.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.54&lt;sup&gt;d&lt;/sup&gt;</td>
<td>28.24&lt;sup&gt;de&lt;/sup&gt;</td>
<td>0.05&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
<td>0.83</td>
<td>0</td>
<td>0.8</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Foot note:

- 1: n=2 reps
- 2: Means in a column with the same letter are not significantly different (p≥0.05)
- The amount of fat was very small to be able its measurement in the Soxhlet. The % of fat in the puddings was considered 0
## APPENDIX E: ANOVA Descriptive Analysis

### Appendix E-1: ANOVA table of sensory attributes for chocolate puddings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source</th>
<th>Df</th>
<th>ANOVA SS</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet</td>
<td>Session</td>
<td>3</td>
<td>18.315</td>
<td>0.994</td>
<td>0.396</td>
</tr>
<tr>
<td></td>
<td>Judge</td>
<td>11</td>
<td>285.928</td>
<td>4.231</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Sample</td>
<td>7</td>
<td>3049.702</td>
<td>70.922</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Session*Judge</td>
<td>33</td>
<td>215.537</td>
<td>1.063</td>
<td>0.382</td>
</tr>
<tr>
<td></td>
<td>Session*Sample#</td>
<td>21</td>
<td>106.892</td>
<td>0.829</td>
<td>0.683</td>
</tr>
<tr>
<td></td>
<td>Judge*Samp#</td>
<td>77</td>
<td>747.161</td>
<td>1.580</td>
<td>0.005</td>
</tr>
<tr>
<td>Chocolate</td>
<td>Session</td>
<td>3</td>
<td>23.684</td>
<td>2.293</td>
<td>0.079</td>
</tr>
<tr>
<td></td>
<td>Judge</td>
<td>11</td>
<td>217.084</td>
<td>5.732</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Sample</td>
<td>7</td>
<td>4306.605</td>
<td>178.682</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Session*Judge</td>
<td>33</td>
<td>149.051</td>
<td>1.312</td>
<td>0.129</td>
</tr>
<tr>
<td></td>
<td>Session*Sample#</td>
<td>21</td>
<td>63.604</td>
<td>0.880</td>
<td>0.618</td>
</tr>
<tr>
<td></td>
<td>Judge*Samp#</td>
<td>77</td>
<td>644.667</td>
<td>2.432</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Beany</td>
<td>Session</td>
<td>3</td>
<td>22.359</td>
<td>2.132</td>
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<tr>
<td></td>
<td>Judge</td>
<td>11</td>
<td>90.002</td>
<td>2.340</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>Sample</td>
<td>7</td>
<td>5376.443</td>
<td>219.671</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Session*Judge</td>
<td>33</td>
<td>238.369</td>
<td>2.066</td>
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<tr>
<td></td>
<td>Session*Sample#</td>
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<td>115.185</td>
<td>1.569</td>
<td>0.058</td>
</tr>
<tr>
<td></td>
<td>Judge*Samp#</td>
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<td>476.595</td>
<td>1.770</td>
<td>0.001</td>
</tr>
<tr>
<td>Grainy</td>
<td>Session</td>
<td>3</td>
<td>21.983</td>
<td>2.942</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>Judge</td>
<td>11</td>
<td>95.859</td>
<td>3.499</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Sample</td>
<td>7</td>
<td>6280.804</td>
<td>360.300</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Session*Judge</td>
<td>33</td>
<td>110.389</td>
<td>1.343</td>
<td>0.110</td>
</tr>
<tr>
<td></td>
<td>Session*Sample#</td>
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<td>109.680</td>
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<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Judge*Samp#</td>
<td>77</td>
<td>280.325</td>
<td>1.462</td>
<td>0.017</td>
</tr>
<tr>
<td>Thick</td>
<td>Session</td>
<td>3</td>
<td>2.743</td>
<td>0.288</td>
<td>0.834</td>
</tr>
<tr>
<td></td>
<td>Judge</td>
<td>11</td>
<td>234.209</td>
<td>6.710</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Sample</td>
<td>7</td>
<td>4059.131</td>
<td>182.759</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Session*Judge</td>
<td>33</td>
<td>124.825</td>
<td>1.192</td>
<td>0.228</td>
</tr>
<tr>
<td></td>
<td>Session*Sample#</td>
<td>21</td>
<td>95.573</td>
<td>1.434</td>
<td>0.103</td>
</tr>
<tr>
<td></td>
<td>Judge*Samp#</td>
<td>77</td>
<td>688.526</td>
<td>2.818</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Appendix E-2: ANOVA graphs for all the attributes interactions

- **Sweet (Judge*samp)**

- **Chocolate flavor (judge*samp)**
Beany (judge*sample, session*judge)

**Reg-Code*Samp#**

**Session*Reg-Code**
Graininess (judge*sample, session*sample)
Thickness (judge*sample)
APPENDIX F: Consent Form Napping

Department of Food Science
50 Stone Road E, Building 038
Guelph, ON N1G 2W1

Consumer Testing of Chocolate Puddings

You are asked to participate in a research study conducted by Lisa Duizer and Thais Honsberger, from the Food Science department at the University of Guelph.

If you have any questions or concerns about the research, please feel free to contact

Lisa Duizer: Faculty member in the Department of Food Science.
    Phone: 519-824-4120 ext 53410.
    E-mail: lduizer@uoguelph.ca

Thais Honsberger: MSc. student researcher in the Department of Food Science
    E-mail: tcastro@uoguelph.ca

Before signing this consent form, you will be provided with a questionnaire to complete regarding food allergies and sensitivities.

PURPOSE OF THE STUDY

To determine the sensory differences present in pudding formulations fortified with soy and whey proteins.

In this study, you will be eating pudding which contain the following ingredients:

- Starch, unsweetened cocoa, sugar, vanilla extract, whey protein concentrate, soy protein concentrate, soy protein isolate and milk

You will also be cleansing your palate with apple and water.
If you know that any of these products/ingredients are likely to cause you discomfort or you are allergic to them, please do not take part in this study.

PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following things:

Individuals will be invited to taste samples of chocolate pudding. All testing will follow a similar format as outlined below.

1. Participants will be served eight samples of pudding to be tested. All samples will be labelled with a random, 3-digit code.
2. Participants will try each of the samples and place them on a paper sheet according to their dissimilarities and similarities. They will be asked to give some attributes for each sample.
3. It is anticipated that a testing session will take approximately 1 hour.

The participants will have the option of giving their e-mail address to receive more information about the aggregate results of the study.

POTENTIAL RISKS AND DISCOMFORTS

The information obtained by this research will help with the development of nutritionally enhanced products with acceptable sensory properties.

There is a standard risk of choking associated with eating any food. This risk will not be any higher than what is encountered in everyday life. There is a risk of allergic reaction and discomfort for individuals with allergies and/or sensitivities to any of the ingredients present in these foods. To prevent any adverse reactions, you have been provided with a list of ingredients and asked to complete a questionnaire regarding any food allergies and/or sensitivities that you may have.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

This research will provide objective information related to the impact of adding soy and whey proteins to a food. This information will help with the development of fortified food products with better sensory attributes.

PAYMENT FOR PARTICIPATION

Participants will receive $15.00 cash as a thank you.

CONFIDENTIALITY
Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study.

After the data has been collected, only the student and faculty members involved with the project will have access to the anything which identifies you. At no time will individual identifiers be released. All data will be averaged and standard deviations will be calculated.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may refuse to answer any questions you don’t want to answer and still remain in the study. Participants will have the right to remove their data from the project. There will be no consequences for doing so.

PROJECT SPONSOR

Omafra: University of Guelph partnership program

RIGHTS OF RESEARCH PARTICIPANTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. This study has been reviewed and received ethics clearance through the University of Guelph Research Ethics Board. If you have questions regarding your rights as a research participant, contact:

Director, Research Ethics
University of Guelph
437 University Centre
Guelph, ON N1G 2W1

Telephone: (519) 824-4120, ext. 56606
E-mail: sauld@uoguelph.ca
Fax: (519) 821-5236
SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I have read the information provided for the study “Sensory Evaluation of Chocolate Puddings” as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_______________________________
Name of Participant (please print)

_______________________________
Signature of Participant          Date

SIGNATURE OF WITNESS

_______________________________
Name of Witness (please print)

_______________________________
Signature of Witness          Date

[The witness is ideally NOT the investigator, but if there is no readily available alternative, the investigator can act as witness.]
APPENDIX G: Older Adults Consent Form

CONSENT TO PARTICIPATE IN RESEARCH

Consumer Testing of Chocolate Puddings

You are asked to participate in a research study conducted by Lisa Duizer and Thais Honsberger, from the Food Science department at the University of Guelph. If you have any questions or concerns about the research, please feel free to contact

Lisa Duizer: Faculty member in the Department of Food Science.

Phone: 519-824-4120 ext 53410.
E-mail: lduizer@uoguelph.ca

Thais Honsberger: MSc. student researcher in the Department of Food Science
E-mail: tcastro@uoguelph.ca

Before signing this consent form, you will be provided with a questionnaire to complete regarding food allergies and sensitivities.

PURPOSE OF THE STUDY

To determine the sensory differences present in pudding formulations fortified with soy and whey proteins.

In this study, you will be eating pudding which contain the following ingredients:

- Starch, unsweetened cocoa, sugar, vanilla extract, whey protein concentrate, soy protein concentrate, soy protein isolate and milk

You will also be cleansing your palate with unsalted soda cracker and water.
If you know that any of these products/ingredients are likely to cause you discomfort or you are allergic to them, please do not take part in this study.

PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following things:

Individuals will be invited to taste samples of chocolate pudding. The participants will be recruited in groups of approximately 10 individuals. All testing will follow a similar format as outlined below.

4. You will be served eight samples of pudding to be tested. All samples will be labeled with a random, 3-digit code.

5. You will be given the list of terms and be asked to select all of the terms on the list that the individual thinks applies to that specific sample. The samples will be served one at the time. After completion, they will be asked to try the puddings again and evaluate according to their overall liking for appearance, taste and texture using a scale that will be range from 0 (‘Dislike Extremely’) to 9 (‘Like Extremely’). Between each sample, water and unsalted soda crackers will be given to the participants in order to clean their palate.

6. It is anticipated that a testing session will take approximately 1 hour.

You will have the option of giving their e-mail address to receive more information about the aggregate results of the study.

POTENTIAL RISKS AND DISCOMFORTS

The information obtained by this research will help with the development of nutritionally enhanced products with acceptable sensory properties.

There is a standard risk of choking associated with eating any food. This risk will not be any higher than what is encountered in everyday life. There is a risk of allergic reaction and discomfort for individuals with allergies and/or sensitivities to any of the ingredients present in these foods. To prevent any adverse reactions, you have been provided with a list of ingredients and asked to complete a questionnaire regarding any food allergies and/or sensitivities that you may have.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

This research will provide objective information related to the impact of adding soy and whey proteins to a food. This information will help with the development of fortified food products with better sensory attributes.

PAYMENT FOR PARTICIPATION

You will receive $15.00 cash as a thank you.
CONFIDENTIALITY

Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study.

After the data has been collected, only the student and faculty members involved with the project will have access to the anything which identifies you. At no time will individual identifiers be released. All data will be averaged and standard deviations will be calculated.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may refuse to answer any questions you don’t want to answer and still remain in the study. You will have the right to remove their data from the project. There will be no consequences for doing so.

PROJECT SPONSOR

Ontario Ministry of Agriculture Food and Rural Affairs : University of Guelph partnership program

RIGHTS OF RESEARCH PARTICIPANTS

I. This project has been reviewed by the Research Ethics Board for compliance with federal guidelines for research involving human participants.

II. If you have any questions regarding your rights and welfare as a research participant in this study (REB #...), please contact: Director, Research Ethics; University of Guelph; reb@uoguelph.ca; 519-824-4120 ext. 56606.

III. You do not waive any legal rights by agreeing to take part in this study.

If you wish to receive a copy of the results, you can provide your email address bellow:

Email: _________________________________________________________
I have read the information provided for the study “Sensory Evaluation of Chocolate Puddings” as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

______________________________
Name of Participant (please print)

______________________________    _____________
Signature of Participant                  Date

SIGNATURE OF WITNESS

______________________________
Name of Witness (please print)

______________________________    _____________
Signature of Witness                  Date

If you wish to receive a copy of the results, you can provide your email address:

Email:
APPENDIX H: Questionnaire CATA and Liking Acceptance

**Consumer liking of chocolate pudding**

**General instructions:** you will be eating 8 different chocolate puddings. Try one at the time and make sure to clean your palate with apples and water between the samples. Take as much time as you need! Thank you for your participation!!!
Sample: # __________

1) How much do you like or dislike the **APPEARANCE** of the pudding? Check **one** of the options bellow

<table>
<thead>
<tr>
<th>Like extremely</th>
<th>Like very much</th>
<th>Like moderately</th>
<th>Like slightly</th>
<th>Neither like or dislike</th>
<th>Dislike slightly</th>
<th>Dislike moderately</th>
<th>Dislike very much</th>
<th>Dislike extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2) Please select all of the attributes you think best describe the **APPEARANCE** of the pudding? You can check **more than one** attribute.

- Dark brown
- Medium brown
- Light brown
- Smooth
- Other: _______________

3) How much do you like or dislike the **TEXTURE** of the pudding? Check **one** of the options bellow

<table>
<thead>
<tr>
<th>Like extremely</th>
<th>Like very much</th>
<th>Like moderately</th>
<th>Like slightly</th>
<th>Neither like or dislike</th>
<th>Dislike slightly</th>
<th>Dislike moderately</th>
<th>Dislike very much</th>
<th>Dislike extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4) Please select all of the attributes you think best describe the **TEXTURE** of the pudding? You can check **more than one** attribute.

- Thick
- Smooth
- Grainy
- Sticky
- Powdery
- Other: _______________

5) How much do you like or dislike the **FLAVOUR/TASTE** of the pudding? Check **one** of the options bellow

<table>
<thead>
<tr>
<th>Like extremely</th>
<th>Like very much</th>
<th>Like moderately</th>
<th>Like slightly</th>
<th>Neither like or dislike</th>
<th>Dislike slightly</th>
<th>Dislike moderately</th>
<th>Dislike very much</th>
<th>Dislike extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6) Please select all of the attributes you think best describe the **FLAVOUR/TASTE** of the pudding? You can check **more than one** attribute.

- Low sweet
- Medium sweet
- Very sweet
- Low chocolate
- Medium chocolate
- High chocolate
- Off-flavour

**OVERALL LIKING OR DISLIKE OF THIS PUDDING**

<table>
<thead>
<tr>
<th>Like extremely</th>
<th>Like very much</th>
<th>Like moderately</th>
<th>Like slightly</th>
<th>Neither like or dislike</th>
<th>Dislike slightly</th>
<th>Dislike moderately</th>
<th>Dislike very much</th>
<th>Dislike extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You can check **more than one** of the above.
APPENDIX I: ANOVA results for Hedonic Scores

Type III Sum of Squares analysis (Variable overall liking):

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of squares</th>
<th>Mean squares</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>sample</td>
<td>7</td>
<td>417.279</td>
<td>59.611</td>
<td>19.335</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Type III Sum of Squares analysis (Variable liking appearance):

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of squares</th>
<th>Mean squares</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>sample</td>
<td>7</td>
<td>293.162</td>
<td>41.880</td>
<td>18.793</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Type III Sum of Squares analysis (Variable liking texture):

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of squares</th>
<th>Mean squares</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>sample</td>
<td>7</td>
<td>399.473</td>
<td>57.068</td>
<td>20.553</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Type III Sum of Squares analysis (Variable liking flavor):

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of squares</th>
<th>Mean squares</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>sample</td>
<td>7</td>
<td>349.749</td>
<td>49.964</td>
<td>16.440</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
APPENDIX J: Preference Map (PREFMAP) Supplementary Tables

J-1: Class centroids

<table>
<thead>
<tr>
<th>Samples/Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.500</td>
<td>3.611</td>
<td>3.500</td>
<td>6.611</td>
<td>4.611</td>
<td>5.500</td>
<td>4.722</td>
<td>7.000</td>
</tr>
<tr>
<td>2</td>
<td>7.375</td>
<td>4.625</td>
<td>6.750</td>
<td>6.750</td>
<td>4.500</td>
<td>5.250</td>
<td>6.000</td>
<td>5.000</td>
</tr>
</tbody>
</table>