

Sorghum-soya biscuits: effect of repeated exposure on consumers' acceptability

by

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DECLARATION

I, Nomsa Chimuti declare that the dissertation, which I hereby submit for the degree of MSc Food Science at the University of Pretoria, is my own work and has not been previously submitted by me for a degree at any other tertiary institution.

SIGNATURE:.....

DATE:.....

DEDICATION

This research is dedicated to the All Mighty God who is my pillar of strength and my source of knowledge.

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ABSTRACT

Sorghum-soya composite biscuits: effect of repeated exposure on consumers' acceptability

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The imbalance between the demand and supply of wheat in Africa has created a need for utilisation of climate smart African cereal grains such as sorghum in the production of a variety of products. However, sorghum as an ingredient is unfamiliar in the South African commercial biscuit market hence thorough consumer acceptability research before any product launch is vital. Traditional consumer sensory research methods to determine consumer acceptability of novel foods might not be sufficient because the measurements are usually limited to immediate impressions. Therefore, a better prediction of acceptability of novel foods such as sorghum biscuits is expected when employing repeated exposure consumer tests.

The first part of the study was done to develop suitable wheat only (control), sorghum only, sorghum-soya and wheat-soya biscuits and characterise the physical, textural properties of these biscuits prior to consumer testing. Adjustments of the formulations, dough handling and baking parameters were necessary to cope with the different properties of the respective flours and doughs. In terms of the physical characteristics, wheat only biscuits were heavier and thicker than the sorghum-soya biscuits. This could be ascribed to the elasticity of the wheat dough which caused the dough to spring back after sheeting resulting in biscuits that are thick and heavy. Wheat biscuits were also found to be harder than sorghum-based and wheat-soya biscuits. Biscuits containing sorghum or soya flour were darker (lower L^* value) and with more redness (higher a^* value) than the wheat-based biscuits. Increased redness in sorghum biscuits was due to the red-pericarp layer of the red non-tannin sorghum flour that was used for preparation of the biscuits. The darkness in sorghum-based biscuits is attributable to the dark brown colour of sorghum flour. The increased yellowness (b^*) in wheat-based biscuits attributed to the wheat endosperm which has a pale yellow colour.

The second objective of this research was to determine the hedonic adjustment potential of the novel sorghum biscuits through conducting repeated exposure testing of biscuits by young adults. Four biscuit formulations used as test material were 100 % sorghum, 100 % wheat, 70:30 sorghum-soya and 70:30 wheat-soya on a flour component base. Participants ($n = 155$)

were randomly allocated to five experimental groups of 31 each. One group did not receive biscuits to consumer for 20 days and this group was called the non-exposure group. The participants in the remaining four groups were given 20 biscuits (1 biscuit type per group) to taste and evaluate, one biscuit per day, for 20 days. All participants however evaluated all four biscuit formulations during the pre-exposure, post-exposure and follow-up test sessions. 100 % sorghum and sorghum-soya biscuits were regarded as unfamiliar or novel biscuits.

For the group that was repeatedly exposed to sorghum-soya biscuits for 20 days, significant increases in liking of sorghum-soya biscuits during the 20-day exposure phase were observed when results of the pre-exposure session were compared to that of the 20-day exposure phase. Results also showed that there was a decrease in liking of 100 % wheat biscuits on day 1 of the 20-day exposure phase for the group that was repeatedly exposed to 100 % wheat biscuits for 20 days when the pre-exposure results were compared to that of the 20-day exposure phase. The decrease in liking for 100 % wheat biscuits is probably due to the fact that, wheat biscuits were indeed not complex to consumers hence exposure to a non-complex stimuli led to boredom and product boredom has been attributed to the decrease in liking of food products during repeated exposure. On the contrary, results obtained from the sorghum-soya group might be due to the fact that the sorghum-soya biscuits were too complex for consumers but over time the complexity or novelty factor gradually reduced which caused an increase in appreciation of sorghum-soya biscuits. The non-exposure group rated wheat-soya biscuits higher than the group that was exposed to wheat-soya biscuits for 20 days. These results could have happened because of product irritation which occurred to the group that was exposed to wheat-soya biscuits for 20 days. Although 50 % of participants showed high neophobic tendencies, food neophobia propensities did not have an effect on liking of all biscuit formulations. This is might have occurred because, 82 % of the participants indicated that they were familiar with sorghum thus their neophobic tendencies did not have an effect on liking of sorghum-soya or 100 % sorghum biscuits.

Findings from this study demonstrate that repeated exposure can be used as a strategy for predicting long-term preferences and potential acceptance of sorghum-soya biscuits. Results also demonstrated that exposure to familiar products can lead to product boredom which causes a decrease in liking.

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1 INTRODUCTION

Sorghum is a climate-smart ancient African cereal grain (Bordoni et al., 2017) that used to form a major part of the diets of indigenous populations in southern Africa. In recent years sorghum production has declined in these parts due to the change in consumers' dietary preferences towards maize, wheat or rice (Orr et al., 2016, Nigatu et al., 2017). However, the production of wheat appears to also be continuously decreasing in Africa (Meyer et al., 2016). The Food and Agriculture Organization (FAO) world food production database (FAO ,2016) reported that between 2000 and 2016 there has been a 21 % decrease in tonnes of wheat produced in Africa. Studies focusing on the effects of climate change on crop production have associated this decrease with the frequent occurrence of drought related conditions on the continent (Adhikari et al., 2015, Bester, 2014, Willenbockel, 2012).

While the supply of wheat is decreasing, the demand is rapidly rising (Osman-Elasha, 2009, Meyer et al., 2016). This rise in demand is attributable to consumers' need for ready-to-eat, sensory acceptable and convenient processed food products from wheat or rice (Cockx et al., 2017, Raihan and Saini, 2017). To curb the dependence on wheat products the adoption of newly developed products from grains such as sorghum and millet has been proposed (Mukarumbwa and Mushunje, 2010, Duze, 2007, Raihan and Saini, 2017). According to Jones and Sheats (2016) the consumption of grain-based products is mainly influenced by factors which include taste, convenience, availability and nutritional value. As such, the development of new sorghum food products that feature the above-mentioned factors might drive consumers' towards the consumption of sorghum products. Thus far products such as biscuits, breakfast porridges, extruded snacks and couscous have been made from sorghum (Aboubacar et al., 2006, Seth and Rajamanickam, 2012).

Research efforts identified that the use of sorghum in biscuit making can improve sorghum utilisation (Adebowale et al., 2012, Bolarinwa et al., 2016). This is because biscuits are widely acceptable to all age groups, have a long shelf life and they are ready-to-eat products (Okpala et al., 2013, Noorfarahzilah et al., 2014). At the same time, there has been research on sorghum biscuits fortified with inexpensive sources of protein such as legume flours (Dovi et al., 2018, Serrem et al., 2011). Fortification of biscuits with protein-rich legume flours has been done with the purpose of developing affordable, high-energy, high-protein on-the-go snacks that addresses the protein and energy needs of consumers (Jackson, 2009). For example, Serrem

(2010) developed sorghum biscuits fortified with soya flour at 28.6 %, 50 % and 71.4 % of the flour component while Dovi (2014) developed biscuits from sorghum and cowpea flours.

Since the current commercial biscuit market is widely populated with wheat biscuits, uptake of novel sorghum biscuits is an opportunity but may require extensive commercial processing and distribution into the retail markets. This will enable consumers to easily access the biscuits. The lack of accessibility to appealing commercial sorghum products limits consumers' familiarity with and interest in sorghum products. Coupled with the fact that sorghum is currently mainly consumed by people living in rural communities in Africa (Vilakati, 2009), the chances of sorghum products being unfamiliar to many modern urban consumers, especially millennials, is high. Therefore, conducting in-depth consumer acceptance research before launch of novel sorghum biscuits is key to obtaining consumer insights.

When conducting product acceptability research, an understanding of the long-term acceptance of the product, especially in the case of a novel food product, is very important. Traditionally, consumer tests involved the evaluation of a small sample of a product in a sensory laboratory setting (Zandstra et al., 1999). These first time judgements are then used to reflect on the product's potential survival in the market (Koster and Mojet, 2012). However, hedonic adjustments or changes in acceptance over time can occur (Kinnear and de Kock, 2011). Moreover, concerns have been raised that the results from a once-off consumer acceptability evaluation test may not be sufficient to conclude on long-term acceptance of novel products (Stubenitsky et al., 1999, Hetherington et al., 2000, Chung and Vickers, 2007b).

In order to determine the long-term acceptance of food products, researchers have suggested the use of repeated exposure test strategies (Weijzen et al., 2008, Chung and Vickers, 2007b). During such tests, consumers taste and evaluate the sensory properties of a single food product over an extended period (Hoek et al., 2013). With a repeated exposure test the assumption is that extended exposure to the food imitates more the actual use situations (Zandstra et al., 1999). Repeated exposure tests are done in order to avoid product market flops (Koster and Mojet, 2012).

An in-home repeated exposure test was conducted in this study to reflect on how the sensory properties of sorghum biscuits will be accepted when the biscuits are consumed in a real life daily situation. This information could provide insight on the long-term acceptance of the biscuits and might highlight requirements for product optimisation and changes. Therefore, the

main objective of this work was to determine the hedonic adjustment potential of sorghum-soya biscuits when consumed repeatedly by young adults over a 20-day period.

2 LITERATURE REVIEW

This review gives a brief summary of the use of sorghum flour as a wheat substitute and the use of such flours in the biscuit industry. The utilization of soya flour as well as the nutritional importance of blending cereal and legume flours in product development is discussed. The psychological theories of food choice development that explains some reasons behind consumers' acceptance behaviour during repeated exposure sensory evaluation of food products are discussed. Empirical studies on repeated consumption of various types of food products are reviewed. The review will also highlight rapid exposure sensory test methods that have been used to measure long-term acceptance of food products. The challenges faced by researchers when conducting repeated exposure sensory evaluation tests are also reviewed.

2.1 Sorghum flour as alternative to wheat

Sorghum (*Sorghum bicolor* (L.) Moench) is an indigenous African cereal crop that has the capacity to survive semi-arid and drought-prone agro-climatic conditions (Belton and Taylor, 2004, Hugo, 2002). In Africa, sorghum is also a cultural staple food that is mainly utilised by people residing in many rural communities (Van Heerden and Schönfeldt, 2004). While the use of sorghum in the feed and beverage industry is popular, the use of sorghum in the production of value-added food products has increased (Rao et al., 2010) but this is not evident in South Africa (Nebe, 2018). According to the FAO (2016), the production of sorghum in Africa increased by 17 % in terms of tonnes produced between the years 2006 and 2016.

Food consumption research by Macauley and Ramadjita (2015) found that the consumption of wheat-based products in sub-Saharan Africa has rapidly increased over the past 20 years. This rising demand for wheat may be attributed to rapid urbanisation, increased population growth, increased income and changes in eating patterns (Cockx et al., 2017). However, the major drawback concerning the growing demand for wheat is that Africa, as a whole, does not produce significant quantities of wheat to meet the domestic demand hence there a widening gap between domestic supply and consumption (Gianessi, 2014). Moreover, it is expected that the production of wheat in sub-Saharan Africa will continuously decrease due to the frequent occurrence of adverse climatic conditions in the region (Adhikari et al., 2015). At the same time, the domestic and world market prices for wheat have significantly increased over the past years (Macauley and Ramadjita, 2015). Due to the above-mentioned challenges, there is great

need of substituting wheat with locally available cereals that are highly adaptable to the harsh African agro-climatic conditions.

Sorghum has been proposed as an alternative to wheat and a priority cereal crop for food security in Africa (Brown, 2013). Sorghum can be milled to flour and it is sold as sorghum meal in the retail markets (Kebakile, 2008). Sorghum flour has been used to partially or fully replace wheat in the development of a variety of food products (Taylor et al., 2006). Due to the fact that sorghum is not yet as popular as wheat and it is viewed as a poor man's cereal (Hugo, 2002), efforts have been directed towards developing products that are sensory acceptable and appealing to the modern society (Williams et al., 2004). Despite the challenge of developing products that have the same sensory and physical properties as wheat, research has shown that products of high sensorial quality such as baked goods, extruded snacks, pasta and breakfast cereals can be produced from sorghum flour (Benhur et al., 2015, Nolte, 2017, Faure, 1992, Omoba et al., 2015).

Furthermore, the main advantage sorghum has over wheat is that it does not contain gluten forming proteins hence it can be tolerated by people suffering from coeliac disease (Taylor et al., 2006). In addition to the absence of gluten proteins, sorghum contains substantial amounts of potential health promoting phenolic compounds (Awika and Rooney, 2004). Public health studies show that the phenolic compounds have antioxidant properties which are known to have effective prevention against chronic diseases such as cancer and diabetes (Pandey and Rizvi, 2009, Mushtaq and Wani, 2013). Khan et al. (2013) found that incorporating sorghum flour in wheat dough for pasta making enhanced the antioxidant capacity because of increased phenolic content in the pasta. Research by Chiremba et al. (2009) indicated that the amount of phenolic content in cookies made with red-tannin sorghum was two times higher than a wheat cookie control. The authors concluded that sorghum cookies are beneficial to human health because of the high antioxidant activity in the cookies.

2.2 Potential use of soya flour in food fortification

Food fortification is a process that involves the improvement of the nutritional value of a specific food by addition of one or more nutrients (Clarke, 1996). Fortification is done for the aim of alleviating a known deficiency that exists among certain populations or within a target population (Dwyer et al., 2015). Generally, micronutrient fortification is by far the most popular and it is done in many developing countries to essentially address diseases caused by iron, iodine and vitamin A deficiency (Sultan et al., 2014). On the other hand, researchers have

identified the increase in the occurrence of macro-nutrient deficiency diseases such as protein-energy malnutrition hence macro-nutrient fortification has steadily increased over the past years (Acevedo-Pacheco and Serna-Saldívar, 2016).

Soya bean (*Glycine max*) is a leguminous oil seed that is recommended as one of the world's cheapest sources of protein (Adelakun et al., 2013). The legume contains exceptionally high amounts of protein compared to other legumes (Day, 2013). The reported protein content of soya bean ranges from 40 % to 43.2 % (Farzana and Mohajan, 2015, Adelakun et al., 2013). Soya flour is a product derived from decorticated milled soya beans (Day, 2013). Owing to the high amounts of protein in soya flour, it has been extensively used to enhance the nutritional protein quality and quantity of cereal-based food products (Acevedo-Pacheco and Serna-Saldívar, 2016).

Currently, soya flour and soya-protein products are popularly used for the production of complementary porridges and biscuits that are specifically used for feeding and nutrition intervention programmes by the United States Agency for International Development (USAID, 2016). In a study by Muoki et al. (2012) defatted and full fat soya flour at varying concentrations of 35 % and 28 %, respectively were used in the fortification of porridge prepared from cassava flour. The authors reported that the extrusion-cooked porridge fortified with full fat or defatted soya flour would meet the recommended daily requirements for protein and lysine contents of infants aged between 6 and 8 months if the porridge was fed to infants thrice per day. The lysine content also increased after fortification of cassava with soya flours.

When Shogren et al. (2006) fortified wheat flour with 50 % soya flour for the production of spaghetti they reported that there was a 117.5 % increase in the protein content. They also found that soya fortified spaghetti had 1.75 % of lysine while wheat flour spaghetti had 0.41 % of lysine. In another study, Ebeler and Walker (1983) partially replaced pearl millet with soya flour in the production of chapattis, they noticed that the protein efficiency ratio (PER) of fortified chapattis was significantly higher (PER = 1.97) than chapattis made from pearl millet flour (PER = 0.73).

2.3 Cereal-legume blends an approach for alleviating malnutrition

Cereals form an important part of the human diet and they are staple foods to millions of people residing in developed and developing countries (McKevith, 2004). Generally, cereals are a major source of energy because they contain about 66 % - 76 % carbohydrates (Koehler and Wieser, 2013). However, the protein quality of cereals flours from the starchy endosperm is

low particularly because of the limiting amino acid lysine which ranges from 1.8 % to 3.3% (Koehler and Wieser, 2013) . For this reason, researchers have implemented several approaches to improve the protein quality of cereals. Some of these approaches include food compositing, food bio-fortification and food supplementation (Anyango et al., 2011).

According to Noorfarahzilah et al. (2014), the technology of compositing flours was first introduced by the FAO in 1964 and the aim was to reduce importation cost by partially substituting wheat flour with other indigenous crops such as sorghum, millet, cassava and yam. Currently, the composite technology has been implemented with the aim of improving the protein quality of cereal-based products (Noorfarahzilah et al., 2014, Anyango et al., 2011). Composite products are essentially made from mixtures of flours from tubers, cereals and or legumes (Iwe et al., 2016). The portion of legume flour added will supply the indispensable amino acid lysine that is limiting in cereals, while cereals will supply the methionine amino acid, which is limiting in legumes (Okpala et al., 2013)

Due to the exceptional nutritional and sensory benefits of cereal-legume complementation, several products such as cookies, pasta, porridges, extruded snacks, breads, cakes and samosas have been developed (Muoki et al., 2012, Nolte, 2017, Noorfarahzilah et al., 2014, Omoba et al., 2015). One of the most popular composite products is the corn-soya blend (CSB) porridge that is widely used by USAID implementing partners for nutritional feeding intervention programmes around the world (USAID, 2016). According to USAID (2016) CSB is a ready-to-use supplementary porridge that was designed to treat moderate malnutrition and prevent wasting in children and adults (pregnant women and lactating mothers in particular). The CSB porridge contains three major components, which are defatted soya flour, yellow corn meal and a micronutrient premix (USAID, 2016).

The production of cereal-legume composite biscuits has been widely reported (Serrem et al., 2011, Omoba et al., 2015) . In 2012, the government of Bangladesh in collaboration with the World Food Programme (WFP) introduced a school feeding programme in drought prone areas to improve the nutritional status of schoolchildren (WFP, 2012). The programme focused on developing and distributing fortified high-energy biscuits prepared from 69 % wheat and 6 % full fat soya flour.

According to Alhassan (2008) the Ministry of Health of Ghana and United Nations Children's Fund also developed a complementary porridge called Weanmix, which was made from blends of roasted maize, soya bean and groundnut flours. The complementary food was designed for

older infants and results from the study by Amagloh et al. (2012) indicated that Weanmix had the potential to improve the nutritional status and growth of the targeted population. Omoba et al. (2015) developed cereal-legume biscuits for nutritionally at-risk school aged children. The biscuits were prepared from fermented or non-fermented pearl millet and sorghum flours fortified with defatted soya flour.

Omwamba and Mahungu (2014) developed a protein enriched ready-to-eat cereal snack from a composite of rice, sorghum and defatted soya flour. The authors found the lysine level of the extruded product to be 1.19 g/100 g and this value is within the daily lysine requirement of 1.0 g -1.5 g for all humans if they consume a 100 g of the extruded product. The researchers also demonstrated that 100 g of the extruded product would provide 45 % of the recommended daily allowance for protein (recommended dietary allowance value of 34 g) for children under the age of 12 years (Omwamba and Mahungu, 2014). In another study Serrem et al. (2011) showed that substituting sorghum or wheat flour with soya flour in biscuit production at ratio 1:1 caused a 500 % to 700 % increase in the lysine content of the biscuits. The author also reported that the protein content of sorghum or wheat biscuits made with 50 % defatted soya flour added provided 7 g of protein per biscuit weighing 28 g.

2.4 Sensory characteristics of gluten free biscuits

Gluten free flours such as rice, sorghum, pearl millet, maize, chickpea, mung bean, cocoyam, cowpea, plantain, defatted soya and bambara have been extensively used in the production of cookies and biscuits (Agu and Okoli, 2014, Dovi, 2014, Noorfarahzilah et al., 2014, Nwosu, 2013, Serrem et al., 2011). Although there has been a steady increase in the demand for gluten-free products, various studies have showed that many of these products exhibit poor, or different to gluten containing products, sensory attributes (Gallagher et al., 2004, Noorfarahzilah et al., 2014, Mahmoud et al., 2013). However, some empirical studies have reported that the acceptability of gluten-free biscuits is comparable to wheat biscuits (Serrem et al., 2011, Bolarinwa et al., 2016).

In research conducted by Omoba et al. (2015) the panellist described 100 % whole grain sorghum biscuits as less crisp, darker, denser and less dry as compared to whole grain wheat biscuits. Badi and Hoseney (1976) described cookies made from 100 % sorghum or pearl millet as gritty, tough and mealy in terms of their taste and texture. In addition, the authors also discovered that the biscuits were dense and compact and during baking, the doughs did not spread. The authors associated the inferior quality of sorghum biscuits compared to wheat

biscuits to the absence of polar lipids in sorghum flour. On the other hand, Taylor et al. (2006) attributed the grittiness to the presence of the corneous endosperm of the sorghum grain.

Okpala et al. (2013) reported that biscuits made from 100 % fermented sorghum flour were less acceptable than a 100 % control unfermented wheat biscuit. Similarly, Mehmood (2015) observed that there was a decrease in overall liking when wheat flour was replaced with 10 %, 20 % and 30 % cowpea flour in biscuits. In contrast, Serrem et al. (2011) reported that sorghum biscuits or bread wheat biscuits fortified with defatted soya were equally acceptable to young children as the biscuits made from sorghum or wheat only. A study by Bolarinwa et al. (2016) revealed that malted sorghum biscuits supplemented with 30 % soya flour had higher overall acceptability scores than a wheat biscuit control.

Negative attributes were reported for wheat sugar cookies where wheat flour was replaced with 33 % and 50 % of cowpea flour, respectively. Panellists described these as having beany, nutty and fishy flavours (McWatters et al., 2003). The authors found that the beany flavour could be reduced by steaming the cowpea flour before baking. Banureka and Mahendran (2011) indicated that as the proportion of soya flour increased in wheat biscuits there was a decrease in the liking of taste and overall acceptability. Though many studies have indicated that there is still low acceptance of non-wheat biscuits, potential ways of improving acceptability and consumption have been researched. Elkhalfa and El-Tinay (2002) found that when cysteine was separately added in wheat-sorghum biscuits there was an improvement in the overall quality of the biscuits. In another study, Shrestha and Noomhorm (2002) observed that fermenting the soya flour improved the sensory quality of the composite wheat-soya biscuits as compared to non-fermented soya flour + wheat biscuits.

2.5 Repeated compared to non-repeated consumer sensory test methods

The main goal of any food manufacturing company is to make profit and this is achievable when there are limited risks of new product failures after launch (Kinnear, 2008, Goldman, 1994). As such, product acceptance consumer tests are usually carried out during the product development process before a decision is made concerning the final launch of a new product in the market (Lévy and Köster, 1999). The conventional consumer sensory tests employ exposure to the product only once, under unnatural testing environment (e.g. in a sensory laboratory) and using a small sample portion of the food product as stimuli (Zandstra et al., 2000, Chung and Vickers, 2007b). The rationale of conventional consumer sensory methods in predicting long-term acceptance and use of the product in a real daily life situation have been questioned due to the above-mentioned factors (Vickers and Holton, 1998, Stubenitsky et al.,

1999). The reasons behind the changes that happen during exposure are thoroughly discussed in literature. Research by Lévy et al. (2006) on repeated consumption of foods indicated that changes in liking that occurs over extended sensory exposure is related to the reduction of perceived novelty and complexity factors.

With repeated exposure tests, the same group of participants are usually given products to taste at home over an extended period of time (Hoek et al., 2013). These tests are usually done at home so that participants can freely rate the product in an environment where the product would be frequently consumed in real-life (Lévy and Köster, 1999). Products are consumed over a long period to investigate whether initial hedonic responses can change with repeated consumption or to observe whether repeated consumption will promote the liking of the particular food (Zandstra et al., 2000, Köster and Mojet, 2006). Repeated exposure tests include evaluation (consumption) of a food product more than once and the result obtained is monitoring the change in liking over time (referred to as “hedonic adjustment” by Kinnear and de Kock (2011). Although some researchers have recommended repeated exposure studies for testing the market acceptance of highly unfamiliar products or generally disliked foods (Keller, 2014, Köster and Mojet, 2012), the numerous challenges associated with conducting repeated exposure studies may prevent a lot of researchers and food companies to conduct such studies. Table 2.1 illustrates some of the major challenges that are associated with conducting repeated exposure sensory evaluation consumer tests.

Table 2.1: Summary of difficulties of conducting repeated exposure sensory consumer tests

Challenge	Possible explanation
Participant attrition	The possibility of participant dropouts is very high in repeated exposure studies because some participants get bored, especially if they have to answer the same type of questions repeatedly, and others forget to complete the questions (Caruana et al., 2015).
Time consuming	It takes a long period to plan, conduct and monitor the study. This planning involves experimental designing, as well as preparation of the participants' questionnaires (Yee and Niemeier, 1996). The actual repeated exposure test also takes days or several weeks to conduct.
Expensive	Repeated use consumer tests are costly and recruitment of participants takes more effort and time than single exposure tests. Repeated exposure studies require a large participant size to counteract the number of participants that may drop out during the course of the study. More funds are also needed to develop, manufacture or buy the greater number of samples required for the study (Caruana et al., 2015)
Difficulty in scheduling the time plan of data collection.	Repeated exposure studies are usually done for several days or months. Therefore, it is difficult to choose the appropriate time to conduct the study because for example the issue of holidays, weekends and celebrations that have to be taken into account before choosing the time plan. (<i>Personal observation</i>)

2.6 Psychological theories of food choice development

In order to explain the underlying reasons behind the changes in food preferences over time, there are several psychological theories that have been developed. These theories reflect on the behavioural aspects and the future changes in behaviour that occur during the learning process (exposure) (Köster and Mojet, 2006).

Among the famous theories relating to repeated exposure is the mere-exposure theory, which was originally developed by Zajonc (1968). This theory assumes that when a person is repeatedly exposed to a stimulus (regardless of its properties) a positive attitude will develop towards the stimulus (Zajonc, 1968). Zajonc (2001) explained the process through which

repeated exposure leads to the development of preferences. The author also reported that at the beginning an individual assumes that a novel stimulus is probably harmful and this induces a response of fear and this may lead to a low initial acceptance. Through exposure, the individual's uncertainty issues concerning safety or identity will gradually wear off and this decrease of uncertainty will then lead to an increase in acceptance of the stimuli.

A few studies have addressed the role of the mere-exposure effect on liking of unfamiliar foods. Pliner (1982) researched the effects of mere-exposure on liking of unfamiliar tropical fruit juices at 20, 10 and 5 exposures. Results from the research indicated that the more the juice was consumed, the more it was liked hence it was concluded that the mere-exposure effect plays a significant role in the development of food preferences. In another study, Birch and Marlin (1982) studied the correlation between frequency of exposure to foods and preferences among 2-year-old children. They expressed that their results were in-line with the mere-exposure theory. In contrast to the above-mentioned studies, Porcherot and Issanchou (1998) discovered that there was a decrease in liking for flavoured crackers after 18 exposures. Similarly, Stubenitsky et al. (1999) reported a decrease in liking of chocolate and sausages over 11 exposures and Zandstra et al. (2000) found the same when meat sauces were consumed repeatedly over 10 exposures. Other researchers did not find any changes in hedonic ratings over repeated exposure. For example, the studies of Hetherington et al. (2000) found no change in liking when consumers were exposed to French fries for 15 days. Similarly, Kahneman and Snell (1992) reported that no change in liking was found when consumers tasted ice cream for 8 days.

Köster et al. (2003) argued that the mere-exposure theory is simply a special case of the arousal theory proposed by Berlyne (1967). This theory was developed based on specific and diversified exploratory behaviour (Köster and Mojet, 2006). According to Köster (2003) the specific explanatory behaviour is a situation where the individual is in a state of conflict due to the absence of information about the identity of the stimulus whereas diversified explanatory behaviour refers to a state where one is no longer in a conflict state because the stimulus properties have become well-known. From the exploratory behaviour mentioned above, Berlyne (1967), Berlyne (1970) deduced that every stimulus has the ability to induce arousal (Giacalone et al., 2014). This arousal involves specific and measurable physiological changes (e.g. brain stem activity), as well as behavioural processes such as attention seeking or focus (Giacalone, 2013). A stimulus' arousal potential relies on three classes of properties which are psychophysical properties (associated with stimulus' intensity and quality), ecological

properties (related to biological functions such as hunger and fear), and collative properties (linked to the individual's attention towards the stimulus such as complexity and novelty (Giacalone, 2013, Lévy et al., 2006).

The ideology of the arousal potential theory by Berlyne (1967) is based on the stimulus collative properties (Lévy et al., 2006). According to this theory, for every person there exists an optimum arousal level which, when reached by a stimulus is liked (Köster et al., 2003). The theory also depicts that when a stimulus arousal level is below or above the optimum level then the stimulus is less liked (Lévy et al., 2006). This is because when the arousal is low a feeling of boredom is induced while when it is high there is a feeling of fear and tension (Giacalone et al., 2014). This theory also assumes that the relationship between arousal potential and hedonic liking occurs through an inverted U-form curve (Köster et al., 2003, Giacalone et al., 2014). This U-form relationship is illustrated in Figure 2.1.

To test this theory, Giacalone et al. (2014), Giacalone (2013) investigated the arousal potential of beer flavour based on three collative properties, which are novelty, familiarity and complexity. Their findings demonstrated that the perceived complexity, novelty and hedonic responses showed an inverted U-shaped relationship as explained by the arousal theory of Berlyne (1967). However, the results for familiarity and complexity did not follow the Berlyne predictions. Lévy et al. (2006), conducted a study on drinks with novel flavours and initial measurements on perceived complexity and liking and indicated that there was no linear relationship, instead the results followed the inverted U-shaped curve as illustrated by the arousal theory.

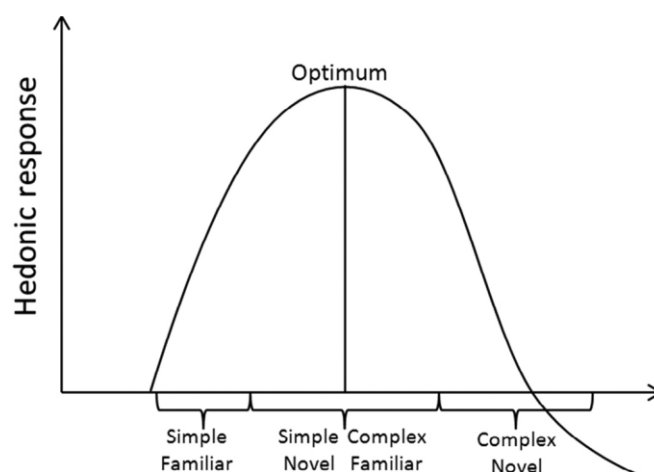


Figure 2.1: The relationship between hedonic response and arousal potential illustrated by Berlyne (1970)

The Dember and Earl (1957) theory is simply an extension of Berlyne's arousal potential theory. In Dember and Earl's theory, perceived complexity is considered as the most important collative property that dominates the arousal potential of a stimuli and this theory explains that perceived complexity significantly decreases with exposure (Lévy et al., 2006). In addition, the theory claims that exposure to a stimulus of a higher complexity will results in a shift of the individual's optimal level towards the direction of a more complex stimulus causing the individual to appreciate the complex product (Lévy et al., 2006). While exposure to a less complex stimulus than the optimal complexity level will lead to an unchanged optimal level (Köster et al., 2003). The illustration of the Dember and Earl (1957) and Berlyne (1967) is shown in Figure 2.2.

Some experiments done on the effect of repeated exposure on acceptance of food have supported the fact that the change in appreciation of a stimulus depends on its initial arousal potential (Sulmont-Rossé et al., 2008, Lévy et al., 2006). Sulmont-Rossé et al. (2008) determined the role of the arousal potential theory on the repeated exposure of uncommon drinks. Their findings were in-line with Dember and Earl's theory, since it was shown that after exposure the liking of drinks with high arousal potential, such as unfamiliar drinks and drinks with low sweetness, increased because the novelty factor worn-off after exposure. For drinks with moderate arousal potential, a decrease in liking was noticed and this was attributed to product boredom. In another study, Lévy et al. (2006) also studied the effect of repeated exposure of seven drinks on perceived complexity and liking. Six of the seven drinks had unfamiliar flavours. The results also supported the Dember and Earl's theory because there was a significant increase in liking for the three drinks that were initially perceived as too complex and for drinks with simple complexity they noticed a decrease in liking with exposure. In contrast to the theory of Dember and Earl (1957), Porcherot and Issanchou (1998) found that the increase in liking for coriander-flavoured crackers was not related to the level of complexity and they noticed that familiar flavours were most preferred.

In addition to the suggestions of the Dember and Earl theory, Walker (1980) showed that experience with a stimulus caused a reduction of the initially perceived complexity and eventually lead to a change in liking (Lévy et al., 2006). According to Magelund (2013) and Walker (1980) the direction of change in liking was mainly influenced by the stimuli perceived complexity in comparison to the individual's optimal perceived complexity. Therefore, exposure to a stimulus that is less complex and above the optimal level will lead to boredom whereas exposure to a less liked complex stimulus leads to a gradual increase in liking over

time (Magelund, 2013). Weijzen et al. (2008) tested the theory when they studied the effect of repeated consumption of soups with different complexities. Their results were in line with predictions of the Walker theory because they found that pleasantness for soups with low arousal levels (less complex) were stable over time while, the pleasantness of soups with the lowest arousal levels (less complex) declined over time.

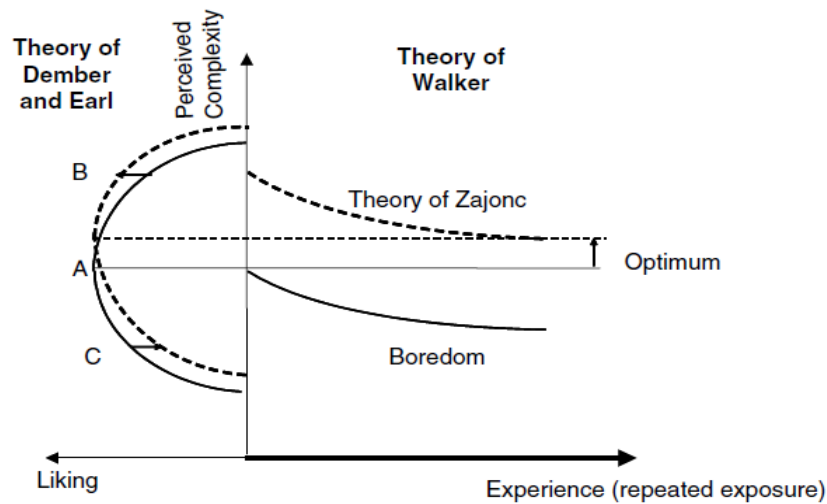


Figure 2.2: A combination of the arousal theories of Berlyne (1970), Dember and Earl (1957) extended by (Walker, 1980). Source : (Lévy et al., 2006).

2.7 Review of some repeated exposure studies available in literature

Once-off and repeated consumption sensory evaluation tests are interchangeably used to determine consumer acceptability of food products (Kinnear and de Kock (2011). The objectives of the two tests are usually different (Stubenitsky et al., 1999). Most researchers who have conducted repeated consumption tests on novel foods have done this with the aim of understanding whether repeated use will promote the liking of novel foods or previously disliked foods (Wardle et al., 2003a, Anzman-Frasca, 2012, Lakkakula et al., 2010), whereas some researchers have simply used the repeated exposure test to measure consumers' reactions towards a particular food when consumed repetitively (Chung and Vickers, 2007b, Hoek et al., 2013) . Table 2.2 provides a review of some empirical research done on repeated exposure of different food products.

Table 2.2: Overview of some studies done on repeated consumption of food

<i>Reference</i>	<i>Objective</i>	<i>Exposure period</i>	<i>Results</i>
Hall et al., 2010	The effect of repeated consumption of seven products (muesli, bread, muffin, chocolate brownie, chocolate milk drink, pasta and instant mashed potato) with or without a novel ingredient (sweet lupin kernel fibre)	4 weeks	No reduction in liking of products containing sweet lupin kernel fibre were noticed over time. However, acceptability was lower for the products with than without lupin.
Lakkakula et al., 2010	To determine whether repeated consumption can increase the liking of vegetables among elementary school children	10 weeks	Repeated consumption enhanced liking of previously disliked vegetables.
Bingham et al., 2005	To determine whether spinach would be liked better over repeated consumption when it is eaten alone or in-combination with other ingredients like cream, cheese and spices.	5 weeks, rated once per week	There was an increase in liking of plain spinach and spinach with cream, cheese and spices by spinach dislikers.
Kremer et al., 2013	Investigated whether salt-reduced bread was more liked with consumption over time	15 days	Liking for salt reduced bread increased gradually but not significantly over the 15 exposures.
Costa et al., 2014	To determine if repeated exposure could be used as a strategy for promoting liking of novel probiotic goat milk yoghurt and normal goat milk yoghurt	6 days	The repeated consumption sessions could not increase the liking for novel probiotic goat milk yoghurt.

Table 2.3: Overview of some studies done on repeated consumption of food (continued)

<i>Reference</i>	<i>Objective</i>	<i>Exposure period</i>	<i>Results</i>
Appleton, 2013	To determine the acceptance of fruits by low fruit intake consumers (65 years and above) through community-based repeated exposures.	5 weeks	Repeated exposure significantly increased the intakes of fruit and vegetables.
Sulmont-Rossé et al., 2008	To investigate the role of stimulus arousal potential on the liking for uncommon fruit drinks through repeated exposure.	24 exposures	Drinks with high arousal potential were more liked over time compared to drinks with a moderate arousal potential
O'Sullivan et al., 2010	To determine the effect of repeated consumption on the liking of reduced energy spaghetti bolognaise	5 days	The liking for reduced energy spaghetti decreased over time while the liking of standard spaghetti bolognaise remained stable.
Hartvig et al., 2015	To explore how repeated exposure could influence the acceptance and intake of two Nordic berry juices (sea-buckthorn and aronia) in primary school children.	8 exposures	Repeated exposure did not significantly enhance the liking of any of the juices.
Kinnear and de Kock, 2011	To determine the effect of repeated exposure on the hedonic adjustment towards sports drinks with different acidulants.	14 days	The sports drinks with low initial hedonic value were continuously liked less over the 14-day period.
Næs et al., 2015	To determine the effects of exposure on consumer acceptance of different types of chocolates	4 weeks	The liking for the new chocolates increased over time while the liking of the market leader chocolate remained stable over time.
Hoek et al., 2013	To investigate the effects of repeated consumption of meat substitutes (Tofu and Quorn) on appreciation.	20 exposures	Tofu and Quorn were less appreciated over time.
Stolzenbach et al., 2013	To determine the impact of repeated exposure on acceptance of local apple juices.	3 weeks	The liking of local apple juices did not change over repeated exposure.

Table 2.4: Overview of some studies done on repeated consumption of food (continued)

<i>Reference</i>	<i>Objective</i>	<i>Exposure period</i>	<i>Results</i>
Hetherington et al., 2002	To investigate whether the intake and acceptance of novel artichoke puree can be promoted through repeated exposure.	10 exposures	There was a significant increase in liking of the novel vegetable puree after 5 exposures.
Stein et al., 2003	To determine the effect of repeated exposure and label information on liking of a bitter beverage.	7 days	Health information as well as repeated consumption enhanced the liking of the bitter beverage
Luckow et al., 2006	To determine whether repeated exposure played a role in the acceptance of probiotic juice	7 days	Repeated exposure played a significant effect on the liking of juice made with probiotic bacteria
Barends et al., 2013	To explore whether repeated exposure could be used to increase the acceptance of fruits and vegetables in weaned babies.	18 days	Repeated exposure increased acceptance of vegetables but not fruits.
Stubenitsky et al., 1999	To examine the effect of repeated exposure, nutritional information and consumer characteristics on liking of reduced fat products.	12 weeks	There were no changes in the pleasantness, idealness and purchase intent towards reduced fat products over time.

2.8 Brief consumer sensory evaluation methods to determine long-term acceptance of food products

There is substantial evidence that when food is repeatedly consumed there can be changes in hedonic responses (Kremer et al., 2013, Kinnear and de Kock, 2011, Stubenitsky et al., 1999), thus it has been disputed that results from the first time tasting have little or no bearing on establishing long-term acceptance of food (Köster and Mojet, 2012). Some studies suggest that long-term acceptance of food can be determined by conducting repeated exposure consumer sensory test for several days or weeks (Weijzen et al., 2008, Kinnear, 2008). Repeated exposure consumer tests are done in such a way that consumers normally taste and rate the acceptability of a single food product over an extended period which can be a few days or weeks (Weijzen et al., 2008). The challenges with such long-term studies were provided in Table 2.1. The question raised by researchers was whether it is possible to design a rapid method of predicting future acceptance of a food product to illuminate the time and expense needed for long term testing.

The one principle that has been thought to underlie repeated food exposure is the habituation effect (Vickers and Holton, 1998, Kremer et al., 2013). According to Havermans and Mallach (2013) habituation is a process which involves learning about a single stimulus such that in the process of learning the individual gets to understand that the stimulus is harmless. Two possible brief exposure test methods, which incorporate the habituation mechanism, include the boredom test and the sensory-specific satiety test (SSS) (Rolls et al., 1981, Rolls et al., 1982, Kremer et al., 2013). The two above-mentioned methods have been suggested as alternative brief-exposure tests that can be used to determine long-term acceptability (Weijzen et al., 2008, Methven et al., 2012, Vickers and Holton, 1998). The validity of the methods in predicting the long-term acceptance of food is important, thus, the methods are discussed in detail below.

2.8.1 Sensory-specific satiety test

Sensory-specific satiation is defined as “the change in pleasantness or liking of a consumed food comparative to the change in liking of unconsumed food” (Hetherington et al., 2006). The sensory-specific satiety test comprises of three main tasting sessions (Rolls et al., 1981). Vickers and Holton (1998) emphasised that the sensory-specific satiety test method has the potential of serving as a rapid method that gives an indication of long-term acceptance of food products because the habituation process is demonstrated in the sensory-specific satiety test. The sensory-specific satiety test is divided into three sessions (Havermans and Mallach, 2013). Firstly, there is the pre-test and during this session, the participants taste and hedonically rate the sensory attributes of a variety of food products which include the test food product (Havermans and Mallach, 2013). The participants are also instructed to indicate that from each food product they have just tasted how much more of it would they would like to eat using a scale with end-points ‘not at all’ and ‘very much’ (Havermans et al., 2010). After the pre-test, participants will receive a large quantity of the test food and asked to eat until they are full. The amount of food consumed by each participant is determined by calculating the weight of the initial food given and the amount of food remaining. The procedure that is done during the pre-test will also be done during the post-test. To determine the increase or decrease in liking of the test food the differences in liking of food during the pre-test and post-test is statistically calculated (Havermans and Mallach, 2013).

Vickers and Holton (1998) conducted a study to investigate whether the sensory-specific satiety test could be used as a quick method to determine long-term acceptability of ice-teas. These authors found that there was an interaction between the quantity of tea consumed to

reach sensory satiety and the long-term acceptance of the teas. They further concluded that results from a sensory-specific satiety test can be used to predict the long-term acceptability of the ice teas because the test included sensory habituation effects. However, Chung and Vickers (2007a) found contradictory results when they evaluated whether the sensory-specific satiety test could be used as a rapid alternative method of determining long term acceptability of sweetened tea. Their results showed that the sensory-specific satiety test did not give an indication of the long-term acceptability of the teas. A study by Weijzen et al. (2008) also demonstrated that sensory-specific satiety test results was not a rapid predictor of long-term acceptance of soup and snacks. Weenen et al. (2005) combined sensory-specific satiety and a repeated exposure test to determine the long-term acceptance of pears and cheese biscuits. The study was done over an 8-day period, the sensory-specific satiety test was done on days one and eight. From the results obtained, the authors proposed that sensory-specific satiety alone should not be used to rapidly predict long-term acceptance but a combination of both methods could give profound results of long-term or future acceptance of food.

2.8.2 Boredom test

During new food product development, the time and cost are some of the key issues that are taken into consideration throughout the product development process. For the reason that, repeated exposure tests are time consuming and expensive, food product developers find it quite challenging to apply (Kinnear, 2008). In order to minimize costs and save time, Köster and Mojet (2007) developed a boredom test to predict long-term acceptance of food products over a short period under well-controlled conditions.

The boredom test is done by comparing the acceptance of a product that already exists in the market with the two or three variations of the test product (Köster and Mojet, 2007). The method is usually conducted using a group of 80-120 consumers or 120-180 consumers if the product to be tested is novel to consumers. If there are two products to be tested, the participants are divided into two groups, one group exposed to each product. The test consists of three main tasting sessions, which include pre, post, and exposure sessions. During the pre-test, each consumer receives all two products and rates the liking of the products on a hedonic scale. Afterwards the consumers in each group will receive 15 small samples of the same product variant and are instructed to consecutively taste and evaluate the samples (repeated consumption task). The consumers are informed that the samples are slightly different while they are actually the same. Finally, in the post-test session consumers are asked again to rate liking of all product variants as they did during the pre-test. Results obtained from the test

highlight the product variant that has a greater potential of surviving in the market and the potentially unsuccessful product/s will be eliminated (Rolls et al., 1981).

In support of the principle of the boredom test, Kremer et al. (2013) gave an example of rapid repeated ingestion that occurs in real life. The authors explained that when a consumer eats a bowl of soup spoon-by-spoon, it is an example of rapid ingestion and changes in liking might be induced as consumption proceeds. It was further explained that effects of sensory habituation are incorporated during the rapidly repeated eating hence the boredom test can be considered as a sufficient measure of long-term acceptance. Porcherot and Issanchou (1998) studied the effects of using a laboratory boredom test and a repeated exposure home use test to predict the long-term acceptance of salty crackers. The authors concluded that the laboratory boredom test was more suitable for predicting a decrease in liking of a product than an increase in liking over time.

A study by Methven et al. (2010) investigated whether long-term liking of two oral nutritional supplements of varied sweetness (standard commercial and sweetness suppressed) can be determined using the boredom test approach. The authors used the modified boredom test designed by Köster and Mojet (2007). In this study, subjects were first presented with 5 ml of each of the two different oral nutritional supplement samples and rated liking of each sample on a 9-point hedonic scale (pre-test). Afterwards the subjects were divided into two groups (one group to taste the commercial standard and the other to taste the suppressed sweetness oral supplement). Each subject in the same group tasted a series of eight samples of 5 ml of the same oral nutritional supplement and rated liking for all the samples (repeated-test). Finally, the same procedure that was done in the pre-test was done for the post-test. The authors mentioned that, changes in liking of oral nutritional supplements over rapidly repeated consumption were noticed and hence this brief-exposure test was appropriate for measuring long-term acceptance of food products. Kremer et al. (2013) evaluated the long-term acceptance of two samples, standard bread (variant 1) and salt-reduced soya sauce bread (Variant 2) using the boredom test approach. Subjects tasted and evaluated samples in the laboratory over three tasting sessions (pre, post and repeated-taste). Liking ratings for the pre-test were different from the post-test hence the authors concluded that boredom test was sufficient in predicting long-term acceptance of salt-reduced soya sauce bread

2.9 Factors influencing food acceptance

The process of food acceptance among humans is very complex and poorly understood (Köster, 2009). McEwan and Thomson (1988), described food acceptability as a human behavioural

phenomenon which results from an interaction between the stimulus and the consumer's response to food. During the eating process, the human brain receives information from multiple sensory modality inputs and this information is incorporated into a final judgement (McEwan and Thomson, 1988, Costell et al., 2010). According to Costell et al. (2010) sensory characteristics of food predominantly influences consumers' acceptance because humans search for food with specific sensory attributes. However, other non-sensory characteristics such as product characteristics (nutritional characteristics and physicochemical properties), consumer characteristics (genetics, age and gender) and environmental aspects (geographic location, religion, education, price, or convenience) are believed to be amongst the key factors that also contribute to consumers' decisions to repeatedly consume or reject food (Barrios and Costell, 2004). All these factors are usually taken into consideration by product developers during new product development to ensure the success of a new product in the market (Torres-Moreno et al., 2012). Several studies have been done on consumers' food acceptance with the aim of elucidating key factors that are considered by consumers when making a decision on food acceptance (Cardello, 1994, Tanaka et al., 2015).

Torres-Moreno et al. (2012), investigated the influence of label information on acceptability of dark chocolates. The researchers compared the acceptability scores of chocolates rated under three conditions, blind (tasting and rating the products without seeing the label information), expected (rating the product by observing the product label information) and informed (rating the product after tasting and observing product information). They found out that the acceptance of chocolates was mostly driven by sensory characteristics rather than information, brand and type of product. In another study, Behrens et al. (2007) also showed that health and nutritional information did have a significant impact on acceptability ratings of soya-milk beverages of high sensory quality. Their study indicated that the consumers did not need additional information to enhance their acceptance of soya milk beverages hence their judgements were dependent on sensory characteristics.

2.10 Personal factors influencing food acceptance during repeated consumption

When hedonic responses are measured over time there can be an increase, decrease or no change in liking over time (Hoek et al., 2013). A number of factors influences the hedonic decisions made by a consumer. Thus, some of the consumer characteristics that influence food acceptance are discussed in detail below.

2.10.1 Food neophobia

Food neophobic behaviour is regarded as a personality trait which makes an individual avoid new foods (Pliner and Hobden, 1992). This personality trait influences how individuals hedonically respond to new food products (Hoek et al., 2013). Food neophobia is also regarded as a barrier to dietary variety because individuals with high neophobic tendencies have a habit of eating the same type of food repeatedly (Tuorila et al., 2001, Leufkens, 2012). On the contrary, food neophilics are individuals who have a higher preference for novel foods than neophobics (Leufkens, 2012). To measure neophobic behaviour in humans, Pliner and Hobden (1992) designed a validated food neophobia questionnaire that consists of 10 questions answered using a 7- point agree-disagree Likert scale.

Research studies concerning acceptability of novel foods have identified food neophobia as a major causative factor behind rejection of new food products by consumers (Fenko et al., 2015, Birch and Marlin, 1982, Arvola et al., 1999). A number of studies have been done to demonstrate how the level of food neophobia in individuals affects acceptance of novel foods. For example, Raudenbush and Frank (1999) conducted a study to characterise the differences between neophobics and neophilics. They observed that, the neophobics were more pessimistic about novel foods compared to neophilics. They also noticed that neophobics were reluctant to try novel foods in the future even after sampling them.

Flight et al. (2003) compared food neophobic tendencies in high school students residing in rural and urban areas. They noticed that city living students were less neophobic and were more willing to try different foods compared to rural-living students. They also noticed that food neophobics gave negative ratings to unfamiliar food. Other studies have suggested that repeated sensory exposure can increase acceptance of new foods among food neophobics (Wardle et al., 2003b, Caton et al., 2013). When Laureati et al. (2014), investigated the effect of repeated exposure to fruits and vegetables in elementary school children with high levels of food neophobia, they showed that 16 exposures were effective in reducing food neophobia. Conversely, Hoek et al. (2013) indicated that food neophobia scores had no effect on the overall liking of meat substitutes over time.

2.10.2 Variety seeking

In many repeated exposure experiments, subjects are given the same type of food to taste for a certain period of time but generally people like variety and they hate monotony (Köster and Mojet, 2016). Hence, the role of consumers' variety seeking behaviour in acceptance of food during exposure is undoubtedly important. To measure variety seeking behaviour, Van Trijp

and Steenkamp (1992) developed a questionnaire with eight items measured on a five-point agree-disagree scale (Table 2.3). Köster and Mojet (2016) explained how consumers' variety seeking behaviour can influence food acceptance using Berlyne's arousal theory of food choice development. They indicated that high variety seekers have a high level of optimal complexity hence they are likely to find many products to be boring and they tend to look for temporal complexity to satisfy their needs. In addition, they illustrated that for low variety seekers their optimal level is low hence, they tend to continuously eat the product that is familiar to them. Hoek et al. (2013), measured variety-seeking behaviour among consumers who were rating liking for meat substitutes over time. The results showed that variety-seeking behaviour had no effect on product liking over time. In contrary, Giacalone et al. (2014) found that high variety seekers gave higher overall liking ratings compared to low variety seekers.

Table 2.5: The eight items of the Varseek-scale (Van Trijp and Steenkamp, 1992)

Rate the items below using a scale, ranging from completely disagree (= 1) to completely agree (=5)

- 1 When I eat out, I like to try the most unusual items, even if I am not sure I would like them
- 2 While preparing foods or snacks, I like to try out new recipes
- 3 I think it is fun to try out food items one is not familiar with
- 4 I am eager to know what kind of foods people from other countries eat
- 5 I like to eat exotic foods
- 6 Items on the menu that I am unfamiliar with make me nervous
- 7 I prefer to eat food products I am used to
- 8 I am curious about food products I am not familiar with

2.10.3 Product familiarity

Product familiarity is related to the knowledge about the product that is derived from previous experiences with and exposure to the product (Borgogno et al., 2015). The fundamental assumption suggested by the mere-exposure theory of Zajonc (1968) is that familiarity breeds liking (Giacalone et al., 2014). Pieniak et al. (2009), explored the relationship between traditional food consumption and motives for food choice, and discovered that familiarity was one of the most important drivers of traditional food consumption. Similarly, when Bevan et al. (2016) studied the relationship between the familiarity and liking of vegetables among children they observed that there was a positive correlation between familiarity and liking scores for vegetables. In another study, Prescott et al. (2004) indicated that lamb patties seasoned in Chinese style were more preferred by Singaporean consumers than patties

seasoned in Indian or European styles. Jaeger et al. (2005) also noticed that the choice of fruits made by consumers were driven by familiarity and that many consumers could not think of any situation in which they would use novel fruits.

A few studies have tried to conceptualize the underlying mechanism between the familiarity-liking relationship. The understanding is that familiarity has a negative correlation with food neophobia (Maratos and Staples, 2015). According to Tuorila et al. (2001), Pliner (1982) suggested that consumers associate unfamiliar foods with risk and danger. A study by Pliner and Hobden (1992) reported that food neophobia was positively correlated with anxiety and fear measures. Visual familiarity is also regarded as an essential concept that aids acceptance of novel foods (Aldridge et al., 2009). Birch and Marlin (1982) conducted a study with children to determine which kind of exposure between looking and tasting will reduce food neophobia more. They reported that visual exposures did not significantly influence taste preferences and they attributed these results to the fact that, unlike taste exposures, visual experience do not contribute to the learned safety.

It was reported that when a consumer tries a familiar product, there is an association between the expectations and product's sensory characteristics (dos Santos Garruti et al. (2012). Hence, consumers' expectations can directly affect hedonic reaction towards new foods. Costa et al. (2014) assessed consumers' expectations before and after tasting familiar and unfamiliar yoghurts. They found out that the expected liking scores before and after tasting familiar cow's milk yoghurt were higher compared to that of unfamiliar goat milk yoghurt.

2.11 Conclusions

The biscuit market is currently populated with a variety of biscuits made from wheat flour. Before the final launch of novel biscuits in the retail market, extensive pre-market research needs to be done. Thus far, progress has been made on the development of biscuits made from sorghum-soya flours. Despite this progress, there is still a knowledge gap regarding the long-term acceptance of such biscuits. Generally, consumer evaluation tests based on single exposure to a small sample of a product are used to predict long-term acceptance. However, the results from a once-off test might provide insufficient insight of what to expect when the product is in the market because the continuous consumers' acceptance behaviour and preferences towards the food product over time might not be reflected during the initial exposure test. In terms of sorghum-soya composite biscuits, attention has been given to the sensory quality and primary first time exposure consumer acceptability. The results from a repeated exposure test s may give a better prediction of whether exposure to the biscuits would

result in an increase, decrease or sustained acceptance of sorghum-soya composite biscuits once they are in the commercial market.

3 HYPOTHESES AND OBJECTIVES

The experimental part of this study is a follow on of the research by Serrem (2010). Serrem 2010 conducted study on the effect of repeated exposure on the acceptability of sorghum, sorghum-soya, wheat-soya and wheat by kids aged between 8 to 9 years. The first part of the study will focus on the manufacture of suitable wheat only (control), sorghum only and sorghum-soya and wheat-soya biscuits to include in a repeated exposure consumer test. Note that adjustment to the formulations, dough handling and baking parameters were necessary to cope with the different properties of the respective flours and doughs. The characterisation of the physical and textural properties of the composite and cereal only biscuits prior to repeated exposure consumer testing, is presented in Chapter 4. The next phase of the research (Chapter 5) reports on the repeated exposure consumer test of wheat only (control), wheat-soya (control), sorghum only, sorghum-soya and biscuits.

The objectives of the first phase of the study (Chapter 4) were:

1. To determine the flour particle size distribution, physical (colour, size, mass) and textural (hardness, strain, strain) properties of wheat only (control), sorghum only, sorghum-soya and wheat-soya biscuits with the aim of characterising the biscuits that were included in the repeated exposure consumer test.
2. To determine the flour particle size distribution of the wheat, sorghum and soya flours and composite flours (wheat-soya, sorghum-soya) used in the study.

The objectives of the second phase of the study (Chapter 5) were:

1. To determine the acceptability of 100 % sorghum, sorghum-soya, 100 % wheat and wheat-soya biscuits when these are consumed repeatedly over a 20-day period, with the aim of predicting market acceptance by millennials.
2. To determine the role of food neophobia propensities, familiarity with sorghum and consumers' enjoyment or boredom with the repeated exposure task on consumer acceptability of 100 % sorghum, sorghum-soya, 100 % wheat and wheat-soya biscuits.

The hypotheses of the second phase of the study (Chapter 5) were:

Hypothesis 1:

Repeated exposure to novel sorghum-soya or sorghum biscuits will lead to higher post-exposure hedonic ratings compared to pre-exposure ratings. In contrast, exposure to familiar wheat biscuits will result in significantly lower hedonic ratings when comparing pre- and post-exposure hedonic ratings. Consumer research of food preferences found that repeated exposure can modify food likes (Pliner, 1982). According to Giacalone (2013) there is an association between hedonic response and arousal potential of stimuli. Arousal potential of a stimulus is influenced by collative properties, which include novelty, familiarity and complexity (Giacalone et al., 2014). According to the theory of Dember and Earl (1957) perceived complexity is the main collative property that influences the arousal potential of a stimuli when novelty diminishes through exposure (Köster and Mojet, 2007). This theory states that when an individual is exposed to stimuli (here considered to be biscuits with sorghum flour) which is more complex than their optimal complexity (presumed here to be wheat biscuits), a shift occurs in the direction of higher liking. In addition, Walker (1980) illustrated that complexity of a stimuli is reduced with experience. Hence a less complex stimulus (familiar product = in this case a wheat biscuit) will initially be liked but later become boring while exposure to a more complex stimulus (novel product = sorghum or sorghum-soya biscuits) will lead to a steady increase in liking and appreciation.

Hypothesis 2:

In the beginning (pre-exposure) consumers with high food neophobia tendencies will hedonically rate novel sorghum-based biscuits low but high hedonic ratings will be noticed during the post-exposure and follow-up sessions. Food neophobia is the fear of new food, studies have revealed that consumers with high food neophobia tendencies tend to perceive new products as dangerous and this induces the feeling of fear which leads to dislike or reject novel foods (Pliner and Hobden, 1992). According to the theory of Dember and Earl (1957) exposure reduces the novelty factor as well as the uncertainty regarding the product's safety which eventually leads to an increase in the appreciation of the stimulus. At the baseline (pre-exposure) those who are familiar with sorghum will appreciate sorghum-soya or sorghum biscuits more than those who are unfamiliar with sorghum. This is because the sorghum-based biscuits will not be too complex or novel for them since they are already familiar with the main ingredient, which is sorghum. As stated by the Walker (1980) consumers who are familiar with the product will not have any uncertainty issues related with the stimuli identity (in this case

sorghum-soya or sorghum biscuits) as a result a less complex stimulus is initially better liked than a more complex stimulus.

4 CHARACTERISATION OF THE PHYSICAL AND TEXTURAL PROPERTIES OF SORGHUM AND WHEAT BISCUITS WITH AND WITHOUT ADDITION OF 30% SOYA FLOUR

ABSTRACT

Sorghum and soya flours have been composited for producing energy-dense and protein-rich biscuits. Apart from their nutritional benefit over sorghum only biscuits, the textural and sensory qualities of such composite biscuits are important. Here, wheat and sorghum biscuits with or without toasted defatted soya flour were made with the objective of characterising their physical, textural properties prior to consumer testing. Adjustments of the formulations, dough handling and baking parameters were necessary to cope with the different properties of the respective flours and doughs. In terms of the physical properties, the weight of sorghum-soya biscuits was lower than that of sorghum only biscuits due to high water added in the dough with defatted soya flour. 100 % wheat biscuits were heavier than all the biscuit formulations because the shrinkage of the wheat only dough caused an increase in the weight and thickness of each wheat biscuit dough. 100 % wheat biscuits were also found to be thicker than all biscuit formulations. Instrumental texture analysis showed that wheat only biscuits were harder and less brittle (higher strain value) than the sorghum-based biscuits. Wheat-soya biscuits were much stronger (higher stress value) than all the formulations. Biscuits containing sorghum or soya flour were darker (lower L^ value) with more redness (higher a^* value). Inclusion of defatted soya flour to the wheat biscuit dough resulted in biscuits with lower yellowness (b^* values). Sorghum-soya biscuits were characterised as dark in colour, soft (low hardness) and brittle in texture.*

Key words: *biscuits, physical properties, instrumental texture properties, sorghum, wheat, defatted soya flour*

4.1 Introduction

Among the various cereal bakery products available in the confectionery market, biscuits are very popular in all segments of the population (Devi and Haripriya, 2014). This is because biscuits are generally affordable, ready-to-eat, convenient and have a long shelf life (Oluwamukomi et al., 2011, Dovi, 2014). Generally, the main ingredient used for biscuit making is wheat flour (Akubor and Ukwuru, 2003). While the consumption of wheat-based products is high, commercial wheat production in Africa is low due to the unfavourable agro-climatic conditions for this crop in this region (Meyer et al., 2016). However, indigenous to Africa, cereal crops that have the ability to thrive in adverse climatic conditions such as sorghum, can also be used in bakery products (Taylor et al., 2006, Olu, 2011, Oluwamukomi et al., 2011, Adedara, 2017). The substitution of wheat flour with domestically grown cereals in the production of baked products in Africa such as biscuits presents a great economic advantage due to the reduction of wheat importation cost (Oluwamukomi et al., 2011).

There are numerous studies on substitution of wheat flour with sorghum in biscuit making (Omoba et al., 2015, Dovi, 2014, Serrem et al., 2011, Adebowale et al., 2012, Elkhalfa and El-Tinay, 2002). In addition, the incorporation cowpea, bambara and soya flour in sorghum flour has been investigated to enhance the nutritional value of sorghum-based biscuits (Serrem et al., 2011, Dovi, 2014, Oluwole and Karim, 2015, Dovi et al., 2018). As such, biscuits made from a combination of cereals and legumes have been successfully considered as snacks that can alleviate diseases such as protein energy malnutrition (Serrem, 2010). While the emphasis is often on development of nutritionally superior biscuits, the physical and textural characteristics are equally important as they contribute to the sensorial acceptability of the product.

Thus, for this part of the research, the focus was on the manufacture of suitable wheat only (control), sorghum only and sorghum-soya and wheat-soya biscuits to include in a repeated exposure consumer test. It is important to remember that adjustments to the formulations, dough handling and baking parameters were necessary to cope with the different properties of the respective flours and doughs. A direct comparison of the effects of flour type (sorghum or wheat) and/or inclusion of 30 % defatted soya flour, were therefore not possible. The aim here was merely characterising the physical and textural properties of the various biscuits that will be included in the repeated exposure consumer test. The flour particle size distribution of the wheat, sorghum and soya flours and composite flours (wheat-soya, sorghum-soya) used were also characterised. The biscuits were manufactured using the procedure from Serrem (2010)

with minor modifications. The addition of 30 % defatted soya flour was a means of improving the protein quality of the biscuits (Serrem et al., 2011). The aim of using sorghum flour was to promote its use in biscuit making instead of wheat.

4.2 Materials and methods

4.2.1 Raw materials

The ingredients used for the preparation of biscuits were all commercially available and purchased in Pretoria and Johannesburg, South Africa. The ingredients were as follows: Sorghum (red non-tannin) “King Corn Fine Mabele Meal” (Tiger Consumer Brands Ltd, Bryanston, South Africa), “Snowflake” cake wheat flour and vanilla essence, both from Premier Foods Ltd, Bryanston, South Africa, “Toasted defatted soya flour” (Petrow Food Ingredients Ltd, Johannesburg, South Africa), “Illovo pure white sugar” (Illovo Sugar Group, Durban, South Africa), “Sunfoil sunflower oil” (Willowton Oil, Pietermaritzburg, South Africa), and “Robertson’s baking powder” (Unilever, Durban, South Africa).

4.2.2 Preparation of biscuits

Table 1 shows the formulations for the four different biscuits types. The dry ingredients, flour, sugar and baking powder, were accurately weighed and mixed in a Diosna electric spiral mixer (Dierks and Sohne GmbH, Osnabruck, Germany). The dry ingredients were mixed at slow speed for 2 minutes. Oil and water were gradually added to the dry ingredients and mixed. Vanilla essence was lastly added and the dough was kneaded at high speed for 7 minutes until a firm dough was formed. The dough from the mixer was divided into smaller dough batches weighing 4 kg each. Each dough batch was sheeted with a Rollfix 300 pastry sheeter (Fritsch, Idar-Oberstein, Germany) to a thickness of 5 mm and cut into circular shapes using a cylindrical steel cutter (diameter 6.3 cm). The cut dough pieces were transferred onto a baking tray lined with silicone baking paper (Bidvest Bakery solutions (Pty) Ltd, Modderfontein, South Africa). The biscuits were baked in a pre-heated Miwe-Condo convention oven (Miwe-Condo 4E, Arnstein, Germany) at 200 °C for 20 ± 5 minutes. Sorghum biscuits with 30 % soya were however baked at 180 °C for 20 ± 5 minutes to avoid burning. After baking, the biscuits were cooled overnight at ambient temperature ~ 20 °C. The biscuits were then packed in polyethylene bags and stored in freezer at -18°C.

Table 4.1: Formulations for sorghum and wheat biscuits composited with or without 30 % defatted soya flour (based on flour weight component)

Ingredients	Wheat : soya		Sorghum: soya	
	100:0	70:30	100:0	70: 30
Wheat flour (kg)	12.5(100) ¹	8.8(70)	- ²	-
Sorghum flour (kg)	-	-	12.5(100)	8.8(70)
Defatted toasted soya flour (kg)	-	3.8(30)	-	3.8(30)
Oil (kg)	3.3(29.3)	3.3 (29.3)	3.3(29.3)	3.3(29.3)
Sugar(kg)	3.1(24.8)	3.1(24.8)	3.1(24.8)	3.1(24.8)
Vanilla essence (kg)	0.3(2.4)	0.3(2.4)	0.3(2.4)	0.3(2.4)
Baking powder (kg)	0.1(0.6)	0.1(0.6)	0.1(0.7)	0.1(0.6)
Water (kg)	4.4(35.5)	5.4(43.2)	2.3(18.1)	5.3(42.6)
Total quantity (kg)	23.7	24.8	21.6	24.7

¹The formulations above were considered as a full mix

²Figures in parentheses are baker's percentages calculated as [mass ingredient (g) /mass of flour (g)]*100
Flours are considered as wheat, sorghum and soya

4.2.3 Flour particle size distribution

The flour particle size distribution (FPSD) of the soya, wheat and sorghum flours and composite flours (wheat-soya, sorghum-soya) were analysed using the sieve analysis method described by Kebakile (2008). Flour (20g) was shifted with a sieve shaker for 5 min through a group of nested mesh sieves of different opening sizes (2000, 1000, 500, 250 µm). After shaking, the flour retained on each of the sieves was weighed. The procedure was repeated twice for each sample. The percentage of flour per particle size was calculated as follows;

$$\% FPS = \left[\frac{\text{Mass of flour in sieve after shaking}}{\text{Initial mass of flour before shaking}} \right] \times 100$$

4.2.4 Instrumental texture analysis

The texture measurements of eight randomly selected biscuits per treatment type, previously refrigerated and left at room temperature overnight, was carried out using an EZ-Test analyser (Model EZ-L, Shimadzu, Tokyo, Japan). Each biscuit was placed on the two steel bars of the 3-point bending rig. The distance between the bars was 30 mm. The test speed was 3.0 mm/s. The maximum force (hardness) and distance compressed before breaking (fracturability) of each biscuit were recorded. Further mechanical properties σ (stress) and ε (strain) were determined according to ASTM standard test methods for textural properties cited by Zucco et al. (2011), Baltsavias et al. (1997).

$$\sigma = \frac{3FL}{2bh^2} \quad ; \quad \varepsilon = \frac{6HY}{L^2} \times 100$$

Where σ is the stress at midpoint (MPa), ε is the strain, F is the force at the beam centre (N), L is the distance between supports or span length (mm), b is the biscuit width (mm), h is the biscuit thickness (mm) and Y is the deformation/deflection at the beam centre under the load (mm). Stress was expressed in kPa and strain as a percentage.

4.2.5 Physical characteristics of the biscuits

The diameter and thickness of biscuits were determined by method 10-50D from AACC International 2000 (Zoulias et al., 2002). The diameter and thickness of eight biscuits that were randomly taken from each treatment were measured using a vernier caliper. Each biscuit was placed edge to edge and the diameter measured. Each biscuit was rotated at a 90 ° angle and re-measured to obtain the diameter. The average diameter was calculated by adding the diameters of all the eight biscuits and dividing by 8. The radius (r) was then calculated by dividing the diameter by 2. The thickness (T) of biscuits was measured by placing each of the eight biscuits on the jaws of the vernier caliper. To get the average thickness the total thickness of the eight measured biscuits was divided by 8. The weight of eight biscuits was measured using an electronic scale. The average weight was calculated by dividing the total weight by 8. The spread ratio, volume and density of the biscuits were calculated according to Zoulias et al. (2002).

$$\text{Spread ratio} = \frac{\text{Width}}{\text{Thickness}}$$

$$\text{Volume (cm}^3\text{)} = r^2 \times T \times 3.14$$

$$\text{Density (g/cm}^3\text{)} = \frac{\text{Average mass of biscuits}}{\text{Average volume of biscuits}}$$

Where T is thickness and r is the radius of the biscuits.

4.2.6 Colour analysis

The surface colour of eight randomly selected biscuits from each formulation was measured using a Konica Minolta Chroma Meter CR-400 (Osaka, Japan). Before measurement was carried out, the Chroma meter was calibrated with a white plate and the readings were; $L^* = 95.98$, $a^* = -0.15$, $b^* = 1.80$. Two readings of the L^* , a^* and b^* values from the top of each biscuit were recorded and averaged. The chroma (C^*) and hue angle, h° were calculated as follows (Khouryieh and Aramouni, 2012):

$$C^* = \sqrt{a^{*2} + b^{*2}}$$

$$h^\circ = \frac{b^*}{a^*}$$

4.2.7 Statistical analysis

Descriptive statistics was used to determine the flour particle size distribution. One-way analysis of variance was performed to determine the physical and texture properties of sorghum or wheat biscuits. Results are presented as mean \pm standard deviation and when the biscuit type effect was significant, the Tukey Honestly Significant Difference (HSD) test was used at $p \leq 0.05$ to compare mean values. All data were analysed by Statistical Package SPSS version 23 (SPSS, IBM, New York, USA)

4.3 Results

4.3.1 Flour particle size distribution

Figure 4.1 shows the particle size distribution of flours used for composite and non-composite biscuits. The particles of commercial cake wheat flour, defatted soya flour and wheat-soya composite flour were the finest flours with 83 %, 81 % and 84 % of the particles passing through a 250 μm sieve, respectively. The addition of defatted soya flour increased the fineness of flours. Sorghum flour had the largest proportion of particles (29 %) between 2000 μm and 1000 μm (Figure 4.1). For all the flours, no particles were observed to be $> 2000 \mu\text{m}$.

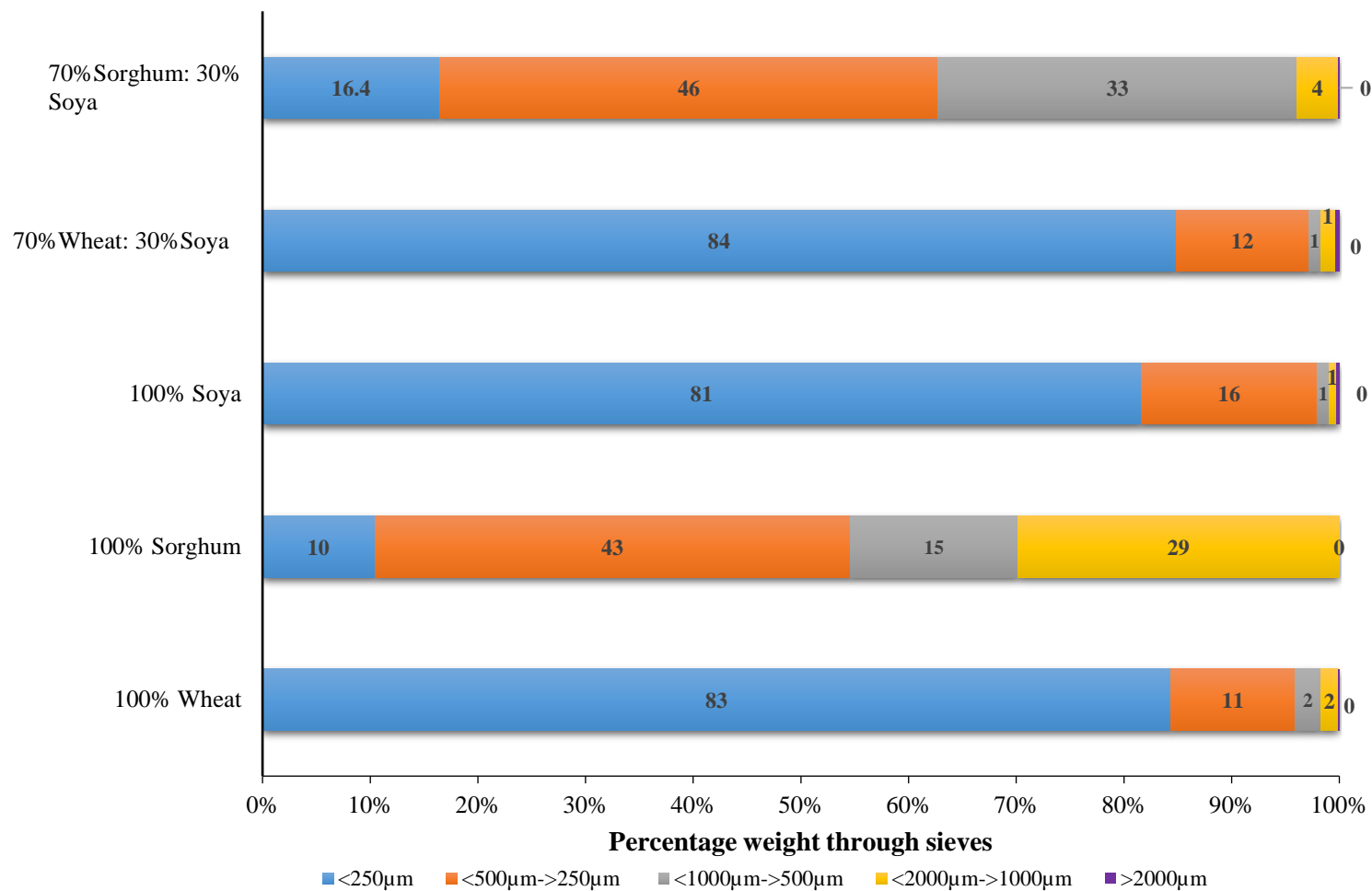


Figure 4.1: Particle size distribution (% particles that pass through various size sieves) of cake wheat, defatted toasted soya, fine sorghum and composite flours.

4.3.1 Instrumental texture characteristics

The means for texture properties of all biscuit types are shown in Table 4.2. Wheat-soya biscuits were much stronger than all the biscuits as indicated by the high stress value (Table 4.2). The stress values of wheat, sorghum and sorghum-soya biscuits were similar ($p > 0.05$). In terms of brittleness, wheat only biscuits were less brittle than the other formulations as shown by the high strain value. Low hardness was observed in sorghum containing biscuits.

Table 4.2: Instrumental texture properties of wheat and sorghum biscuits composited with or without defatted soya flour.

Biscuit type	Hardness (N)	Distance to fracture (mm)	Stress (MPa)	Strain (%)
100% Wheat	159.7 ^a ± 3.6	2.7 ^a ±0.2	799.6 ^b ±129.6	12.9 ^a ±1.1
100% Sorghum	22.2 ^c ± 0.3	0.8 ^b ±0.5	531.0 ^b ±62.7	6.1 ^b ±0.4
Wheat : Soya 70 : 30	61.7 ^b ± 12.9	1.6 ^{ab} ±0.7	1343.1 ^a ±126.6	6.4 ^b ±0.4
Sorghum : Soya 70 : 30	30.7 ^c ± 2.0	1.3 ^b ±0.1	795.1 ^b ±89.3	5.9 ^b ±0.14

¹Values are presented as means of 8 biscuits ± standard deviation

²Means in the same column with different superscripts are significantly different ($p < 0.05$)

4.3.2 Physical characteristics

The physical characteristics of biscuit samples are shown in Table 4.3. Sorghum-soya biscuits had higher spread ratio than other biscuit formulations. Wheat biscuits were significantly heavier, with a larger diameter and thicker than all biscuit formulations.

Table 4.3: Physical characteristics of wheat and sorghum biscuits composited with or without defatted soya flour.

¹Values are presented as means of 8 biscuits \pm standard deviation

Biscuit type	Weight (g)	Diameter (mm)	Thickness (mm)	Spread ratio	Density (g/cm³)
100% Wheat	20.6 ^a \pm 1.3	59.1 ^a \pm 1.9	15.7 ^a \pm 1.5	3.9 ^c \pm 0.4	0.05
100% Sorghum	16.5 ^b \pm 0.5	55.1 ^b \pm 1.0	8.0 ^{bc} \pm 0.4	7.0 ^b \pm 0.3	0.09
Wheat : Soya 70 : 30	13.1 ^c \pm 1.3	55.7 ^b \pm 1.6	8.7 ^b \pm 0.3	6.4 ^b \pm 0.4	0.06
Sorghum: Soya 70 : 30	15.4 ^b \pm 0.3	55.5 ^b \pm 1.1	7.4 ^c \pm 3.4	7.5 ^a \pm 0.3	0.09

²Means in the same column with different superscripts are significantly different ($p < 0.05$)

4.3.3 Colour properties

Table 4.4 shows the means for colour attributes of biscuits. As expected, wheat biscuits were lighter in colour (higher L* value). In general, there was a decrease in L* values with the addition of soya flour in the biscuits, indicating that soya flour made the biscuits darker. Sorghum only, sorghum-soya and wheat-soya biscuits were more red (higher a* values) than wheat biscuits. Sorghum based biscuits were the same in terms of a* values ($p > 0.05$). Wheat biscuits were more yellow compared to the other biscuits as indicated by a higher b* value. Sorghum containing biscuits had the lowest b* values. Overall, wheat only biscuits were lighter in colour than sorghum containing biscuits thus a higher colour intensity ($C^* = 26.9$).

Table 4.4: Instrumental colour properties of wheat and sorghum biscuits composited with or without defatted soya flour.

Biscuit type	L*	a*	b*	C* (chroma)	h° (hue)
100 % Wheat	69.1 ^a ± 1.7	5.2 ^c ± 1.2	24.6 ^a ± 1.2	26.9 ^a ± 0.6	76.7 ^a ± 1.4
100 % Sorghum	52.5 ^b ± 2.0	9.4 ^{ab} ± 0.7	15.6 ^c ± 0.9	19.9 ^b ± 1.3	58.9 ^b ± 1.8
Wheat: Soya 70 : 30	52.6 ^b ± 1.5	9.9 ^a ± 0.9	18.8 ^b ± 1.6	18.9 ^b ± 1.2	62.4 ^b ± 1.6
Sorghum: Soya 70 : 30	47.6 ^c ± 1.2	9.1 ^b ± 0.4	14.7 ^c ± 0.7	17.74 ^b ± 0.7	60.5 ^b ± 1.3

Values are presented as means of 8 biscuits ± standard deviation

Means in the same column with different superscripts are significantly different ($p < 0.05$)

The wheat and sorghum biscuits differed in thickness (Table 4.3) hence direct comparison of texture values was problematic.

4.4 Discussion

4.4.1 Textural properties

Textural characteristics are one of the most important quality attributes of biscuits (Pereira et al., 2013). Sorghum-based biscuits were less hard and more brittle (low strain) than wheat only biscuits. This is similar to what was reported by Serrem et al. (2011) and Badi and Hosene (1976). Serrem et al. (2011) associated the low hardness of sorghum-based biscuits with the lack of gluten forming proteins in sorghum flour. At least two theories have illustrated the mechanism behind the hardness of wheat biscuits. Firstly, hardness of wheat biscuits has been correlated with the presence of the visco-elastic gluten network (Pauly et al., 2013). It has been reported that gluten network development in biscuit dough is undesirable as it leads to product hardness (Wada et al., 1991, Pareyt and Delcour, 2008). It has been argued that gluten development rarely occurs in biscuit doughs (Adedara, 2017, Gallagher et al., 2004), however it has been demonstrated that if the creaming method is not used during dough mixing then an extensive gluten network can develop (Pareyt and Delcour, 2008). In this study, the creaming method was not used, instead all ingredients were mixed together while water was added slowly. There is a high possibility that a gluten network developed to a large extent. Hence it is probable that the rubbery gluten network that formed remained in a thermoplastic state which aided moisture loss during baking and upon cooling a hard glassy thermoplastic material which contributed to the biscuit hardness was formed (Slade et al., 1989). Contrastingly, the low hardness noticed in wheat-soya composite biscuits could be because of weakening of the gluten network due to the addition non-gluten forming soya flour (Lauterbach and Albrecht, 1994).

Secondly, biscuit hardness has been strongly associated with the particle size of flour used for biscuit baking (Zucco et al., 2011). Zucco et al. (2011) reported an increase in hardness with addition of fine flours. Presumably, this could have contributed to the hardness of wheat biscuit because commercial cake wheat flour was finer than the fine meal sorghum flour used. It has also been reported that finer flour particles have a tendency of absorbing a great amount of water (Nkhabutlane et al., 2014) causing the biscuit dough to be more stiff and increasing cookie hardness (Barak et al., 2014).

Wheat-soya composite biscuits were stronger (higher stress value) than all biscuit formulations. Barac et al. (2004) reported that when globulin proteins in soya flour are heated at temperatures above 70 °C there is disassociation and denaturing of proteins which enables the formation of protein aggregates through electrostatic or hydrophobic interactions hence the globulin proteins could have interacted with the gluten network to form strong fibre-like networks. These

findings were in accordance with what was reported by Serrem (2010) who found high maximum stress in wheat-soya biscuits composited at a ratio of 78.6:21.4. 100 % wheat biscuits were found to be the least brittle (higher strain value). This is possibly due to the strong associations formed between the starch and the gluten network in wheat biscuits (Adedara, 2017).

4.4.2 Physical properties

100 % wheat biscuits were thicker and heavier than sorghum-based biscuits and wheat-soya composite biscuits (Table 4.2). This could be attributed to the high elasticity caused by gluten in 100 % wheat dough, there was great shrinkage after sheeting such that the thickness and mass the 100 % wheat biscuits were heavier and thicker than all biscuit formulations. Similarly, Cheng and Bhat (2016) observed that wheat cookies were heavier than those supplemented with jering (*Pithecellobium jiringa*) legume flour. The results are also in accordance with those of Abu-Salem and Abou-Arab (2011). These authors noticed a significant decrease in weight of cassava-soya composite biscuits with increasing levels of soya flour in the biscuits. The decrease in weight of wheat biscuits after substitution with soya flour could be attributed to the high amount of water added in wheat-soya dough. It is also possible that the soya proteins do not have the ability to retain moisture during heating hence more water is expelled causing a reduction in total solids in the dough (Serrem, 2010). The greater thickness of 100 % wheat biscuits might also be ascribed to the presence of the gluten network in the wheat dough that has the ability to entrap gas during baking (Uchenna and Omolayo, 2017). Fustier et al. (2007) correlated biscuit thickness with dough elasticity. They found that following the sheeting process, the thickness of the dough will increase due to partial strain recovery. Conversely, kafirin and globulin proteins have poor gas-holding properties (Belton et al., 2006) hence these proteins are unable to yield biscuits with increased thickness.

Spread ratio is derived from the biscuit thickness and diameter (Ade et al., 2012). Wheat biscuits or cookies with a high spread ratio are considered to be of good quality (Chauhan et al., 2016). High spread ratio values observed in sorghum-soya biscuits are probably due to the low dough viscosity of the sorghum and sorghum-soya doughs. According to Noorfarahzilah et al. (2014) when the water content in the dough is high, more water is available to dissolve the sugar so the dough viscosity becomes lower causing the biscuits to spread at a faster rate during baking. Doughs containing soya flour required more water to be workable as compared to cereal only doughs (sorghum and wheat dough) (Table 4.1). This is ascribed to the fact that soya globulin proteins contain a high proportion of glutamic and aspartic acid which makes

them more hydrophilic compared to gluten and kafirin proteins found in wheat and sorghum, respectively (Xiao et al., 2014, Nehete et al., 2013). In agreement to the high spread ratio values found in sorghum-soya biscuits, Chauhan et al. (2016) revealed that cookies made from wheat flour had a lower spread ratio compared to those composited with protein-rich amaranth flour. The low spread ratio of wheat biscuits could have been related to the gluten network, which causes an increase in the dough viscosity and stops the spread of the biscuits during baking (Ho and Abdul Latif, 2016). Kaldy et al. (1993) also reported a decrease in cookie spread with increasing levels of gluten in the cookies.

The diameter of sorghum-based biscuits was significantly lower compared to 100 % wheat biscuits. When Mridula et al. (2007) studied the physical properties of wheat based biscuits incorporated with sorghum and soya flour, they discovered that diameter of biscuits decreased with increasing levels of sorghum in the composite biscuits. Adeyeye (2016) also noticed that the diameter of sorghum cookies was smaller compared to wheat cookies. Smaller diameter of sorghum based biscuits was possibly caused by the high levels of damaged starch in sorghum flour. Damaged starch absorbs a greater amount of water which leads to increased dough viscosity and decreased biscuit diameter (Barak et al., 2014). The diameter of sorghum-soya biscuits was similar to sorghum biscuits but in the diameter of wheat-soya biscuits was lower due to the incorporation of defatted soya flour. Different results were reported by Abu-Salem and Abou-Arab (2011) who observed that the addition of a legume flour (Bambara ground nut) in wheat-bambara composite biscuits caused an increase in diameter of the biscuits.

Biscuits prepared with commercial wheat flour were lighter in colour and the L* values decreased with the incorporation of defatted soya flour in composite biscuits (Table 4.4). The absence of a bran pericarp layer in cake wheat flour could have been the cause of the lighter colour in wheat-based biscuits (Dovi, 2014). Chauhan et al. (2016) also found that wheat cookies were lighter in colour and the lightness reduced with the addition of amaranth flour. The dark colour (lower L* value) of sorghum biscuits is due to the dark brown colour of sorghum flour. Dykes et al. (2005) suggested that the darker colour of the sorghum flour is related to the high levels of phenolic compounds. The incorporation of toasted defatted soya flour has already been shown to impart a dark colour in biscuits due to the brown pigments produced when Maillard browning reaction occurs during biscuit baking (Adeyeye, 2016). Chauhan et al. (2016) also reported that protein content of flour is negatively correlated with lightness of cookies. The redness was high in sorghum based biscuits and wheat-soya composite biscuits. The redness (low a*) of sorghum-based biscuits is probably due to the

presence of the red pericarp layer (Awika and Rooney, 2004) of the red non-tannin sorghum grain flour that was used to prepare the biscuits. Several studies have reported on high redness values in sorghum products. For example, Mridula et al. (2007) demonstrated that the redness in sorghum-wheat-soya composite biscuits increased with increasing levels of sorghum flour in composite biscuits. The yellowness (b^*) in wheat-based biscuits is because wheat endosperm has a pale yellow colour (Matz, 1991).

4.4.3 Conclusions

This chapter focused on characterizing the biscuits that were used as test materials in the repeated exposure consumer test. The textural and physical measurements showed that sorghum-soya biscuits had higher spread ratio, lower weight and softer (less hardness) than wheat only biscuits. The brittleness (strain) of sorghum-soya and wheat-soya biscuits were comparable. Wheat-soya biscuits were generally stronger in texture (higher stress value) than the other biscuits. Wheat biscuits were harder (high hardness values) and less brittle (high strain values) compared to the other biscuits. Sorghum-soya biscuits were darker and more red (higher a^* values) than wheat-based biscuits. Sorghum biscuits were slightly lighter (higher L^* value) in colour than sorghum-soya biscuits. Wheat biscuits were more yellow (higher a^* value) compared to all biscuits. Thus, the aim of this chapter which was to determine the physical, textural and colour properties of the biscuits that were used as test materials for the next phase of this research, which is the repeated exposure test, was fulfilled. The results obtained on this chapter will also be used to clarify and describe some results that will be found in chapter 5.

5 THE EFFECT OF REPEATED EXPOSURE ON CONSUMERS' ACCEPTANCE OF SORGHUM AND WHEAT BISCUITS COMPOSITED WITH OR WITHOUT 30% DEFATTED SOYA FLOUR.

ABSTRACT

Among the greatest causes of flops of new food product in the market is the issue of conducting inadequate pre-market research. Conventional consumer sensory evaluation tests might not provide an insight on the long-term acceptance of food. Traditional test methods usually consider measurements based on first-time impressions. Novel food products are usually complex and sometimes consumers need time to learn and familiarise themselves with the product before they make a final decision about the acceptance of the product. The objective of this research was to determine the hedonic adjustment potential of novel sorghum biscuits through conducting repeated exposure testing of the biscuits by young adults. Four biscuit formulations used as test material were 100 % sorghum, 100 % wheat, 70:30 sorghum-soya and 70:30 wheat-soya on a flour component base. Participants (n=155) were randomly allocated to five experimental groups of 31 each. Participants in one of the five groups did not receive any biscuits to consume during the 20-day exposure phase. The participants in the remaining four groups were given 20 biscuits (one type per group) to taste and evaluate, one biscuit per day for 20 days. All participants however evaluated all four biscuit formulations during the pre-exposure, post-exposure and follow-up test session. For the group that was repeatedly exposed to sorghum-soya biscuits, significant increases in liking were observed on some days of the 20-day exposure phase. No change in liking of sorghum-soya biscuits was noticed when comparing results from the pre, post and follow-up sessions. The liking of sorghum-soya biscuits during the pre, post and follow-up sessions by the group that was exposed to sorghum-soya biscuits for 20-days, was not different from that of the group that was not exposed to any biscuits for 20 days (non-exposure group). Repeated exposure to sorghum-soya biscuits by the sorghum-soya experimental group led to an increase in liking. Repeated exposure can be used as a strategy for predicting long-term preferences and potential acceptance of sorghum-soya biscuits.

Key words: *repeated exposure, pre-exposure, post-exposure, follow-up sessions, 20-day exposure phase*

5.1.1 Introduction

Sorghum is unfamiliar in the biscuit baking industry hence before launching sorghum biscuits into the commercial market many factors have to be put into consideration. For example, Taylor and Awika (2017) reported that sorghum is still regarded as the poor man's crop therefore the chances that modern consumers especially millennials, will consider sorghum products as inferior is high. In addition, sorghum might be unfamiliar to modern consumers because it is more a staple to those mainly residing in the rural areas (Vilakati, 2009). Due to the above mentioned factors there is great need for conducting a thorough consumer research using the appropriate consumer research methods before making a decision on launch.

Before product launch, developers usually conduct the standard once-off consumer acceptability test in a laboratory setting where consumers get to evaluate a small sample of the product (Köster and Mojet, 2007). Traditionally, once-off consumer tests were developed to predict the long-term acceptance of food (Zandstra et al., 2000). However, the use of results from once-off laboratory tests for prediction of real-life consumption or long-term use can be misleading (Kinnear, 2008, Chung and Vickers, 2007b). This is because research has shown that hedonic adjustments can occur through repeated consumption of the product (Stubenitsky et al., 1999, Zandstra et al., 2000, Porcherot and Issanchou, 1998).

Repeated exposure tests have therefore been suggested to be an effective method of determining the long-term acceptance of food (Zandstra et al., 2000, Chung and Vickers, 2007b, Kinnear and de Kock, 2011, Köster and Mojet, 2012). The concept behind this test is that a longer exposure period imitates normal daily life eating situation (Zandstra et al., 2000). It has been shown that an increase in acceptance might occur after the initial try out because at first some consumers might dislike the food due to the fear of trying new food (food neophobia) but after repeated consumption the negative attitudes toward the new food might wear-off (Lévy et al., 2006). A decrease in acceptance can also happen due to the product or boredom with the experiment (Lévy and Köster, 1999, Sulmont-Rossé et al., 2008) .

The extent to which repeated exposure affects food acceptance is vital to food product developers because they want to ensure that consumers like their products and want to try it repeatedly especially after the initial try out (Goldman, 1994). The main objective of this research was to determine the hedonic adjustment potential of novel sorghum biscuits when they are repeatedly consumed over a 20-day in-home repeated exposure test.

Recruitment (155 participants, Age- 18 to 26 years, test material-biscuits)

Consumer Sensory evaluation (9-point hedonic scale)

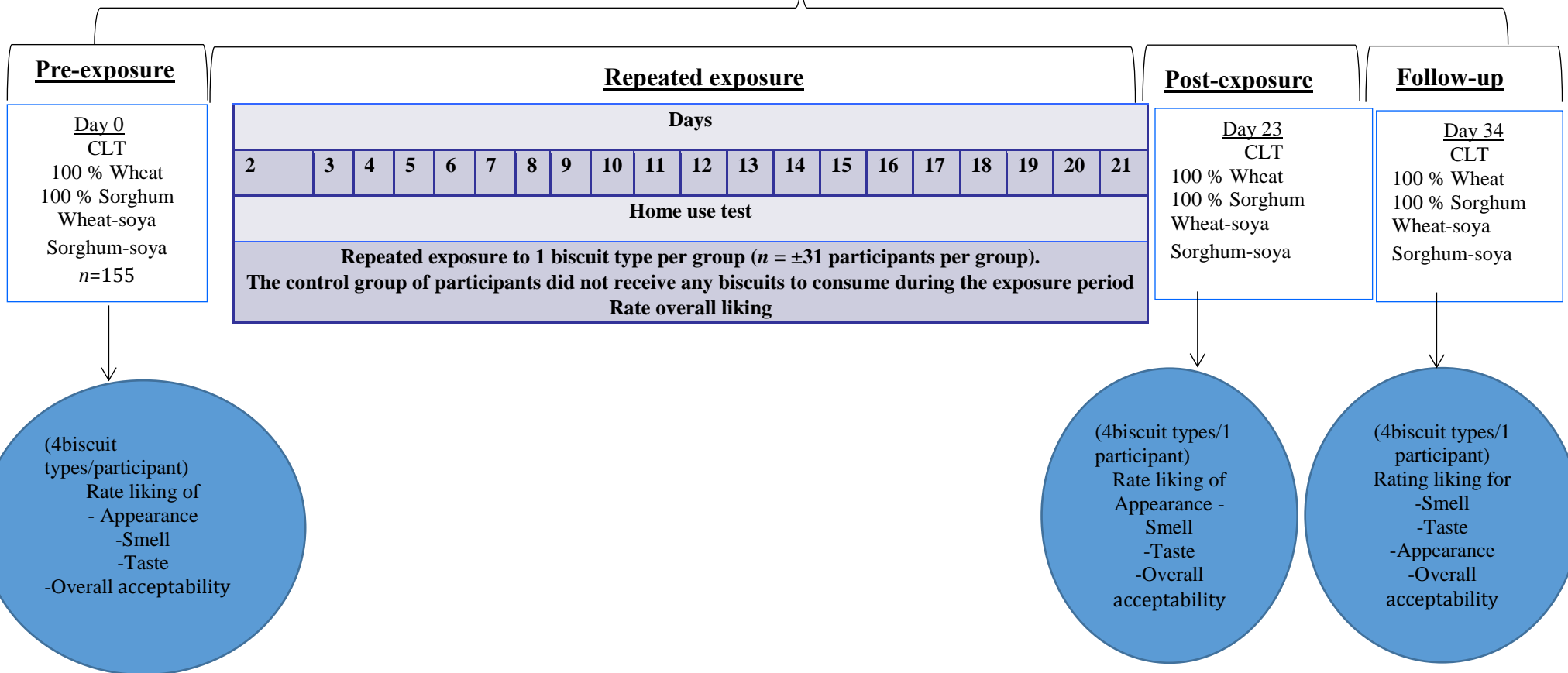


Figure 5.1: Design of the experiment to measure the effect of the repeated exposure to sorghum and wheat based biscuits composited with or without defatted soya flour on consumer acceptance. The design was based on research by Ghawi et al. (2014)

5.1.2 Test Materials

Biscuits that were used as test samples were 100 % sorghum, 100 % wheat, 70 % wheat, 30 % defatted soya and 70 % sorghum, and 30 % defatted soya on a flour component basis. 100 % wheat biscuit was the control. The preparation of the biscuits was described in the materials and methods section in research chapter 4. The addition of defatted soya flour in the cereal flours was done for the purpose of improving the protein quality of cereal-based biscuits. The biscuits used as test materials are shown in Figure 5.2.

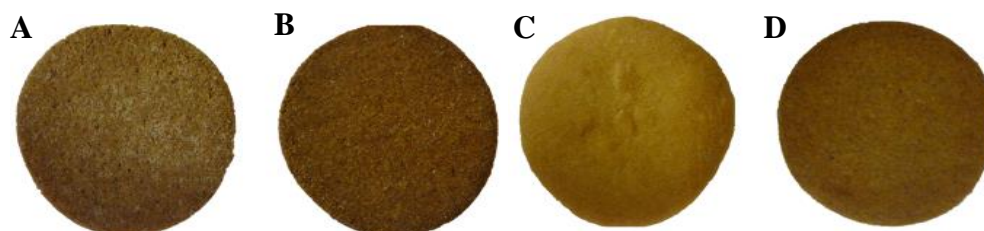


Figure 5.2: Images of biscuits used as test materials; A. 100% sorghum flour. B. 70:30 sorghum-soya flour. C. 100% wheat flour. D. 70:30 wheat-soya flour

5.1.3 Study participants

The participants were recruited by a recruitment agent in Pretoria, South Africa. The recruitment agent was given the recruitment letter (**Appendix 1**) and a screening form (**Appendix 2**). The recruitment agent then recruited participants via word of mouth and participants who did not meet the study requirements were excluded from participation. Participation in the study was voluntary and all participants signed a consent form (**Appendix 3**) before participating in the study. The recruited participants were 155 students and staff residing at a private student residence located in Pretoria, South Africa. The residence is called West city residence and the students residing in this residence attend Tshwane University of Technology located in Pretoria, South Africa.

5.1.4 Study design

The study was divided into four phases (**pre-exposure, repeated exposure, post-exposure and one follow-up sessions**) as shown in Figure 5.1. Participants were randomly divided into 5 experimental groups of 31 each. After the pre-exposure session, each participant received a calendar with 20 biscuits in total, one biscuit attached to the date they were supposed to taste and evaluate the biscuit. Groups A, B, C and D received 100 % wheat, 100 % sorghum, 70 % wheat: 30 % defatted soya and 70 % sorghum: 30 % defatted soya biscuits to consume one per day during the 20-day exposure phase, respectively. Group E served as the control group and they did not receive any biscuit to consume at home during the 20-day repeated exposure phase

but they participated in the **pre-exposure**, **post-exposure** and **follow up sessions**. The activities that occurred during the four tasting phases are described below.

5.1.5 Evaluation procedure

5.1.5.1 *Pre exposure session*

The pre-exposure session was the first sensory evaluation session of the study. The pre-exposure evaluation included five time slots. Each slot was attended by 31 participants and the evaluation took place at the study centre of the residence. This was done so to divide participants into 5 experimental groups. During the pre-exposure tasting session, each participant was sequentially presented with one biscuit from each of the four types of biscuits in random order following a Williams design. Each biscuit was served in a small zip lock bag and labelled with a three-digit random code generated with Compusense cloud® software (Compusense, Ontario, Canada). Bottled water was served as a palate cleanser. The study questionnaire was online and participants were instructed to open the web URL using phones, tablets or computers. The participants were instructed to taste each biscuit in the order presented from left to right and rate the acceptability of each biscuit in terms of liking of appearance, smell, taste and overall liking using a labelled 9-point hedonic scale with endpoints of (1) =‘like extremely’ and (9) =‘dislike extremely’ (**Appendix 4**) (Peryam and Pilgrim, 1957).

5.1.5.2 *Repeated consumption and post exposure sessions*

Participants completed the 20-day repeated exposure phase and post exposure phases at home. Each participant in the experimental groups that participated in the 20-day exposure session received a calendar with 24 biscuits attached. Each biscuit was attached to the date that the biscuit was supposed to be eaten (1 biscuit per day for 20 days of repeated consumption and 4 biscuits for the post exposure tasting session). Participants from the non-exposure group only received 4 biscuits for the post exposure session. Participants were not informed that the 20 biscuits for repeated exposure were the same. Every day during the repeated home consumption phase, participants used the same web URL to access the questionnaire. They were also reminded via email daily to complete the questionnaire. During this period, consumers rated the overall liking of the biscuits on the same 9-point hedonic scale. On days 1, 10 and 20 participants also answered a question about their intent to purchase the biscuits using a 5-point scale with end points labelled 1 = definitely will not buy to 5 = definitely will buy (**Appendix 7**). On the last day of the repeated exposure, participants rated the liking of the experience of participating in the repeated exposure task using two different scales with endpoints labelled 1

= not fun at all to 5 extremely fun and 1 = extremely boring to 5 = not boring at all (**Appendix 8**). On day 21 (post exposure session) all participants including individuals in the non-exposure group tasted four biscuits one from the four biscuit types in random order and rated how much they liked or disliked the biscuits using the 9-point hedonic scale with endpoints labelled 9 = like extremely to 1 = dislike extremely. Participants were also asked to comment on anything regarding the biscuits or the exposure experience and this was done in the comment section that was provided on each of the questionnaire of the 20-day exposure phase.

5.1.5.3 *Follow-up session*

The follow-up session was conducted 10 days after the post-exposure session. The tasting session was done at the same central location where the pre-exposure session was conducted. The participants were presented with four biscuits in random order (one per biscuit type) and asked to rate the acceptability of biscuits in terms of appearance, smell, taste and overall liking using the 9-point hedonic scale. During this session, the participants' attitudes towards new foods were measured using a ten statement food neophobia questionnaire originally designed by Pliner and Hobden (1992) (**Appendix 5**). Participants were also instructed to rate the importance of each of the 36 statements of the Food Choice Questionnaire by Steptoe et al. (1995) on a 4-point scale labelled (1) = not at all important, (2) = little important, (3) = moderately important, and (4) = very important (**Appendix 6**). A comment section was also included in the follow-up questionnaire, in the comment section participants were asked to write their views on the exposure experience. Familiarity with sorghum was also measured and 1 was used to indicate familiarity with sorghum, while 2 represented non-familiarity with sorghum.

5.2 Statistical analyses

Descriptive statistics were used to report gender distribution and the percentages of participants that spoke specific home languages. To assess the internal consistency, the Cronbach alpha values for the overall Food Choice Questionnaire (FCQ) and the 9 factors (health, mood, convenience, sensory appeal, ethical concern, price, natural content, weight control) were calculated as per Steptoe et al. (1995). Cronbach alpha values were also calculated for the Food Neophobia Scale (FNS). One-way ANOVA was conducted to determine if there was a significant difference in the motive factors driving food choice for the group of participants in the study (dependant variable – 9 motives of food choices). One-way repeated measures ANOVA was used to investigate if there were changes in liking of the four biscuit types during the 23 sessions of evaluation (dependant variable – liking of biscuits). Here, the overall liking scores for the four biscuit types measured at 22 evaluations were compared (20-day repeated exposure phase, post-exposure ratings and follow-up ratings) with the pre-exposure ratings. The means for biscuits were separated using Fisher's LSD test.

The effect of experimental group \times evaluation session (pre-exposure, post exposure and follow-up) on the overall liking ratings of biscuits was analysed using the mixed-model ANOVA approach with between subject factor (experimental group) and within subject factor (evaluation session). Two-way repeated measures ANOVA was used to investigate the effect of biscuit type (within subject factor) \times evaluation session (within subject factor) and their interactions on hedonic ratings of appearance, smell, taste and overall liking. The effect of exposure or non-exposure on overall liking of biscuits was investigated using a mixed model ANOVA approach. The independent variables were time (within subject factor) and exposure vs non-exposure group (between subject factor).

The food neophobia scores were determined by calculating the total score of the 10 questions of the FNS for each individual. Prior to the calculation of the neophobia scores, the scores for neophilic questions were reversed so that all measures of the scale went in the same direction such that 7 = 1, 6 =2, 5=3, 4=4, 3= 5, 2= 6 and 1 =7 (Pliner and Hobden, 1992). To determine whether participants were neophobic or neophilic, descriptive statistics was done and the FNS scores were split into two quartiles based on the group medians [low food neophobia (neophilics) \leq 38 and high food neophobia (neophobics) \geq 39]. Descriptive statistics were also used to determine the percentages of participants who had high or low neophobia tendencies in the five experimental groups. The effect of food neophobia propensities were also

investigated using a mixed model anova [between subject factor; group (high neophobia vs low neophobia) and (within subject factor (evaluation session))].

Descriptive statistics was used to determine the % of participants who were familiar and unfamiliar with sorghum. The effect of familiarity or unfamiliarity with sorghum x evaluation session on the overall liking of all biscuits types was analysed using a mixed model ANOVA [between subject factor; group (familiar vs unfamiliar) and (within subject factor (evaluation session))]. Where significant differences were found during the one-way repeated measures ANOVA, two-way repeated ANOVA and mixed model ANOVA tests, post-hoc tests were done using the Bonferroni correction.

The test of association between consumers' exposure experience (enjoyment/boredom) and overall liking of biscuits during the 20-day exposure phase was conducted using the Spearman rank order correlation. The differences between the purchase intent ratings for biscuits during day 1, 10 and 20 were analysed using one-way repeated measures ANOVA. Table 5.1 shows a summary of the objectives and statistical methods used to analyse the repeated exposure data. All statistical analyses were done using SPSS version 23.00, IBM New York, USA.

Table 5.1: Summary of the objectives and statistical methods used to analyse the repeated exposure data

Objective	Statistical method
1. To assess the main factors that were considered by consumers when making food choices using the food choice questionnaire by Steptoe et al. (1995).	One-way ANOVA
2. Effect of repeated consumption on the overall liking of biscuits by each experimental group that participated in the 20-day exposure phase i.e. was there an increase or decrease or no change in liking for wheat, sorghum, wheat-soya and sorghum-soya biscuits with repeated exposure over 20 days?	One way repeated measures ANOVA
3. To determine the effect of the evaluation session on the overall liking of biscuits by all experimental groups i.e. where the biscuit hedonic ratings of the experimental groups are different or similar during the pre-exposure, post-exposure and follow-up session?	Mixed model anova measures ANOVA

Table 5.1: Summary of the objectives and statistical methods used to analyse the repeated exposure data (continued)

Objective	Statistical method
4. To determine the effect of repeated consumption on the hedonic ratings for smell, taste, appearance and overall liking of wheat, sorghum, wheat-soya and sorghum-soya biscuits (pre-exposure, post-exposure and follow-up sessions)	Two-way repeated measures ANOVA
5. To assess whether repeated exposure/consumption had an effect on overall liking of biscuits (exposure vs non-exposure groups) i.e. were the hedonic ratings of the groups who were exposed to biscuits for 20 days similar to the control group?	Mixed model ANOVA
4. To assess whether consumers' food neophobia propensities had an effect on the overall liking ratings of all biscuits types during the pre-exposure, post-exposure and follow-up i.e. did food neophobia behaviour of participants influence liking of the biscuits?	Mixed model ANOVA
7. To determine the % of participants who are familiar or unfamiliar with sorghum and whether familiarity had an effect on the overall liking ratings for wheat, wheat-soya, sorghum and sorghum-soya biscuits as measured at the three sessions (pre-exposure, post-exposure and follow-up)	Mixed model ANOVA
8. To determine whether there was a correlation between the liking scores of the wheat, sorghum, wheat-soya and sorghum-soya biscuits and the boredom and/or enjoyment of the experience of participating in the repeated exposure biscuit tasting project i.e. is there a relationship between the liking of the biscuits and boredom or fun ratings related to the experiment?	Spearman's rank order correlation
9. To determine the differences between the purchase intent ratings of biscuits during day 1, 10 and 20 of the repeated exposure phase.	One way repeated measures ANOVA

5.3 Results

In total, 103 participants managed to complete all 23 evaluation sessions and the data of participants who dropped out were excluded from statistical analysis. The participants were aged between 18 and 26 years, 45% males and 55% were females. Comments of participants on biscuits and the experience of the 20-day exposure phase are shown in appendix 9, 10, 11, 12 and 13.

5.3.1 Demographic results

Figure 5.3 shows the home languages of participants.

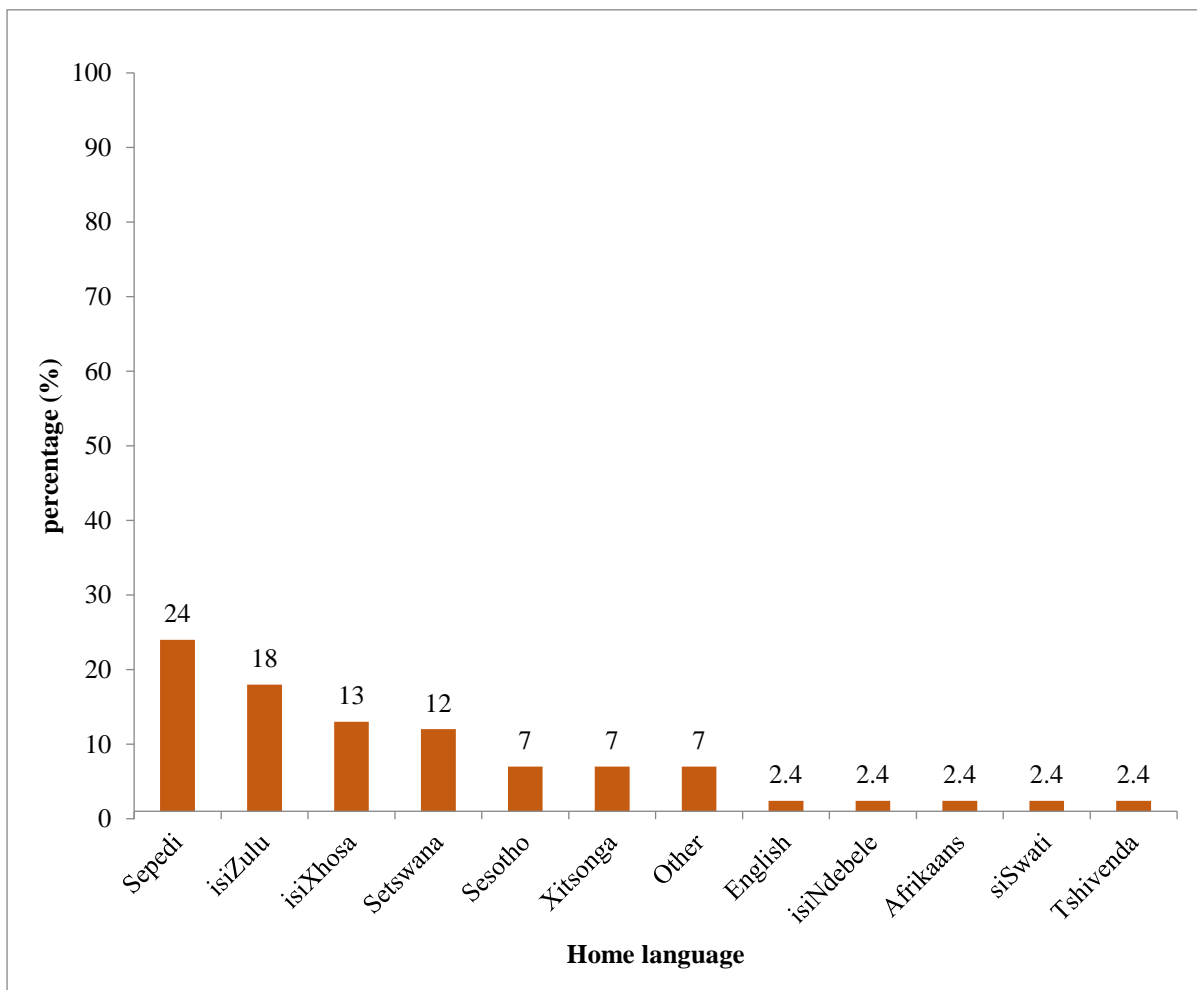


Figure 5.3: Distribution of % of participants ($n = 103$) speaking different home languages

5.3.2 Food choice motives of participants

The motives behind the food choices made by consumers who participated in this study were assessed using a 36 question food choice questionnaire (FCQ) designed by Steptoe et al. (1995). The 36 questions of the FCQ are divided into 9 factors which are *health, mood, convenience, sensory appeal, ethical concern, price, natural content, weight control* and *familiarity*. The internal consistency for the 36 questions of the FCQ was found to be 0.73. The internal reliability scores of each factor of the FCQ were as follows: health= 0.69, mood=0.77, convenience=0.69, sensory appeal=0.72, natural content=0.69, price=0.65, weight control=0.72, familiarity=0.65 and ethical concern=0.74. The reliability scores were determined with the aim of assessing the consistency of the participant's scores (Golafshani, 2003). One-way ANOVA demonstrated that there was a significant difference among the mean scores for the 9 factors of the FCQ. The results in Figure 5.4 demonstrate that the participants in this study considered health and sensory appeal as the most important factors when making their food choices. Ethical concern was rated as the least influencing motive when making food choices. Natural content, price and convenience were also considered important after health and sensory appeal.

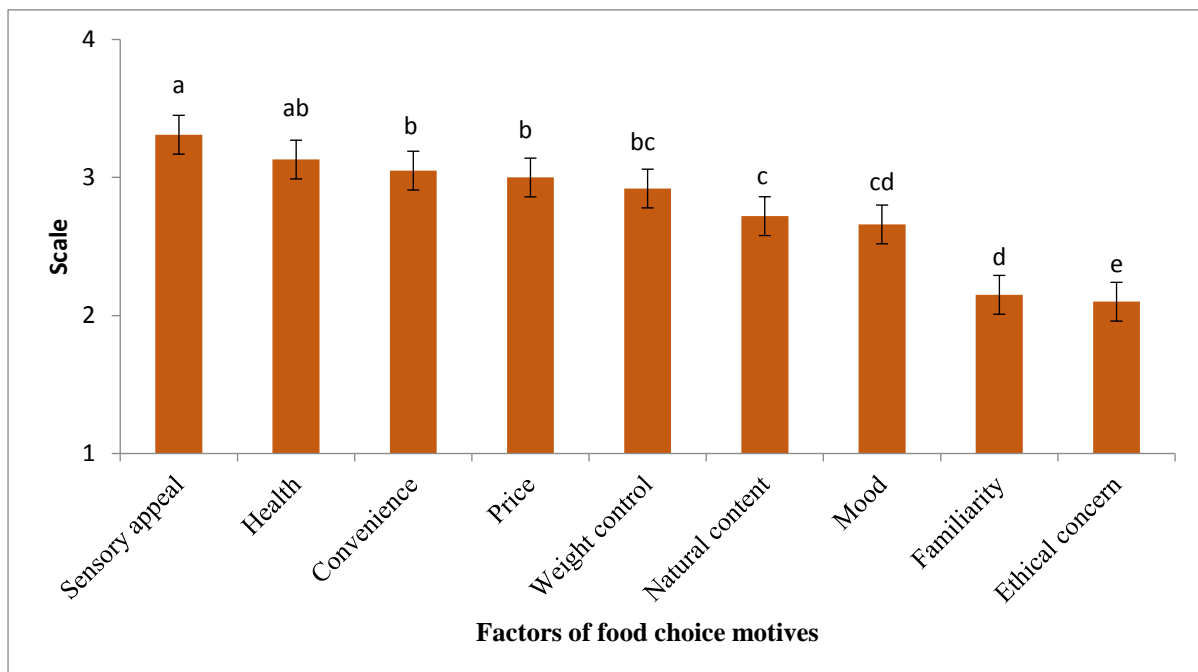
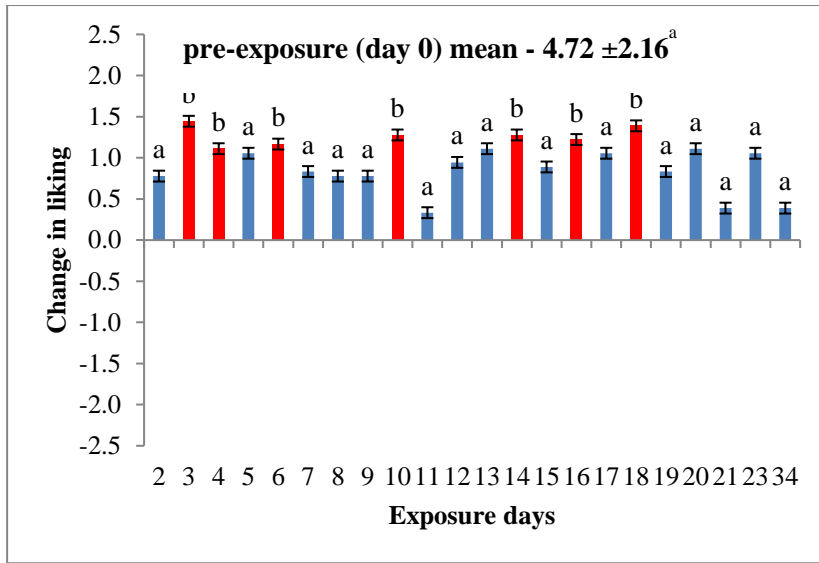


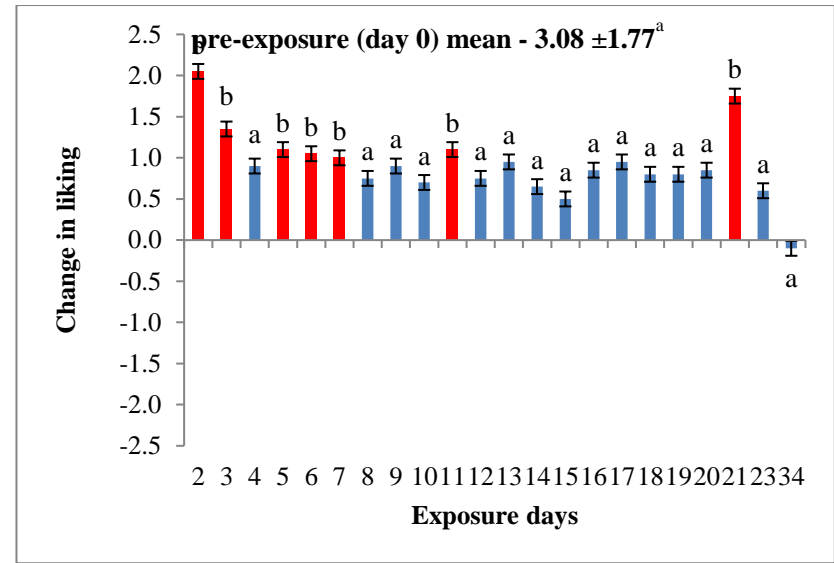
Figure 5.4: Scoring of motive factors driving food choice of the group of participants ($n = 103$). Food choice motive ratings 1 = not important at all, 2 = little important, 3 = moderately important, 4 = extremely important.

5.3.3 Effect of repeated exposure on the overall liking of biscuits by each experimental group that participated in the 20-day exposure phase

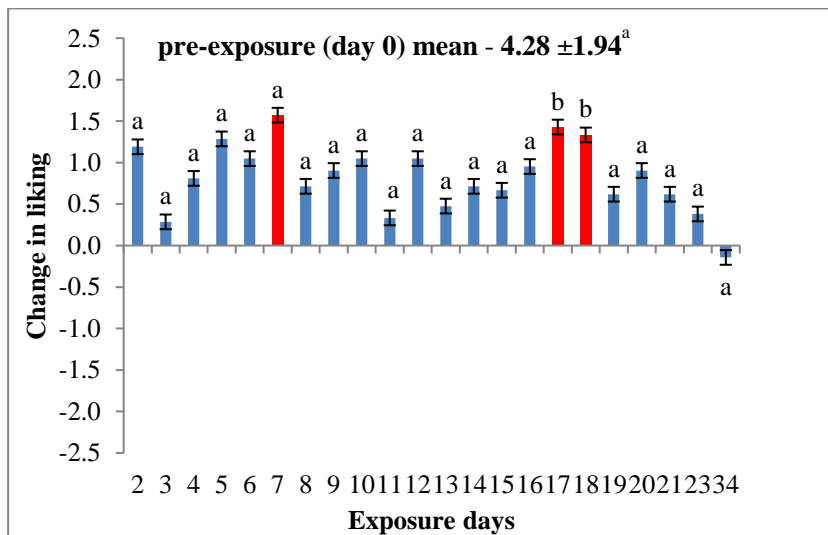
One-way repeated measures ANOVA was done to investigate the effect of exposure (time) on the overall liking of each biscuit type by each experimental group that participated in the 20-day exposure phase (Figure 5.5). The mean rating of 4.72 ± 2.16 for the sorghum-soya biscuits was significant lower ($p \leq 0.05$) at the pre-exposure session compared to ratings on days 2, 3, 5, 9, 13, 15 and 17 of the 20-day exposure phase. The mean rating for the 100% wheat biscuits during the pre-exposure session (6.02 ± 2.43) was significantly higher compared to the mean rating only on day 1 of the repeated exposure phase. For 100% sorghum biscuits there were significant increases ($p \leq 0.05$) in liking of the biscuits during day 6, 16 and 17 of the in comparison to the pre-exposure mean rating (4.28 ± 1.94). The graph also shows that for wheat-soya biscuits the mean score at the pre-exposure session was significantly lower (3.08 ± 1.77) than ratings on days 1, 2, 4, 5, 6, 10 and 20 of the repeated exposure phase.



70:30 Sorghum-soya ($n = 18$)

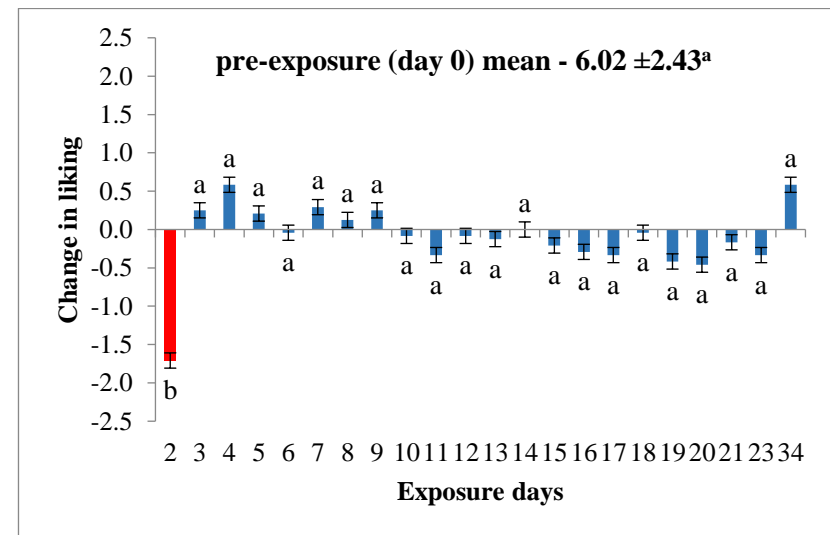


70:30 Wheat-soya ($n = 20$)



100 % Sorghum ($n = 21$)

54



100 % Wheat ($n = 24$)

Figure 5.5: Mean change in liking ratings for biscuits during the exposure phase compared to day 0 (pre-exposure) evaluation. Day 23- post exposure, day 34 – follow-up. Hedonic rating on a 9-point hedonic scale 9=Like extremely. Bars in red indicate significant difference in liking ($p \leq 0.05$). For each biscuit type, mean values with a's did not differ significantly from the day 0 mean, but mean values with b's did ($p \leq 0.05$)

5.3.4 The effect of biscuit type x evaluation session on overall liking as rated by the control group (n = 20) (group not exposed to biscuits for 20 days)

Table 5.2 shows the results of the mixed model ANOVA including biscuit type, evaluation session (pre-, post and follow-up) and the interaction effect of these factors on overall liking as assessed by the control group (the group that did not participate in the 20-day repeated exposure phase). There was no significant interaction between biscuit type x evaluation session [$F = (6,251.1) = 0.9; p > 0.05$] on the overall liking of all biscuits as rated by participants. This shows that, for this group, the overall liking scores of sorghum-soya, wheat, sorghum and wheat-soya did not change over the three sessions (pre-exposure, post-exposure and follow-up).

Table 5.2: The effect of biscuit type x evaluation session on the overall liking of all biscuits as rated by control group (n = 20) (group not exposed to biscuits for 20 days)

Sources of variation	Sum of squares (ss)	Degrees of freedom (df)	Mean of squares (ms)	F value	p-value
<u>Overall liking</u>					
Biscuit type	44.6	3	14.9	2.7	ns
Session	3.03	2	1.5	0.4	ns
Biscuit type*session	12.6	6	2.1	0.9	ns

ns- not significant

Measurement of overall liking was done using a 9-point hedonic scale with points of 9=Like extremely, 8= Like very much, 7=Like Moderately, 6 Like Slightly, 5= Neither like or dislike, 4=Dislike slightly, 3= Dislike moderately, 2= Dislike very much, 1= Dislike extremely

5.3.5 The effect of experimental group x evaluation session (pre-exposure, post exposure and follow-up) on the overall liking ratings of biscuits

Table 5.3 shows that there was no interaction effect between group x evaluation session for the overall liking scores for sorghum-soya biscuits [$F(8, 173.3) = 0.4, p > 0.05$]. The main effect of group was significant [$F(4, 98) = 3.7, p \leq 0.05$] such that the control group rated sorghum-soya biscuits higher (4.8 ± 2.3) than the experimental group exposed to wheat-soya (2.7 ± 1.7) during the pre-exposure session. The control group also rated sorghum-soya biscuits lower (3.3 ± 1.6) than the wheat or sorghum-soya exposed experimental groups. There was no a significant interaction effect between group and evaluation session for wheat biscuits [$F(8, 173.0) = 0.8, p > 0.05$], however the main effect of evaluation was significant such that wheat biscuits were more liked during the follow-up session as compared to the pre-exposure and post exposure session (Table 6.5).

Table 5.3: The effect of experimental group x evaluation session on the overall liking of biscuits

Sources of variation	Sum of squares (ss)	Degrees of freedom (df)	Mean of squares (ms)	F value	p
<u>100% Wheat biscuit</u>					
Group ^b	117.2	4	29.3	3.9	< 0.05
Session	19.9	2	11.3	5.7	< 0.05
Group*Session	11.7	8	1.7	0.8	ns
<u>100% Sorghum biscuit</u>					
Group	82.5	4	20.2	2.6	< 0.05
Session	12.7	2	7.1	2.4	ns
Group *Session	21.3	8	3.0	1.0	ns
<u>70:30 Wheat:Soya biscuit</u>					
Group	84.2	4	21.1	2.9	< 0.05
Session	5.7	2	2.8	1.1	ns
Group*Session	18.1	8	2.3	0.9	ns
<u>70:30 Sorghum:Soya biscuit</u>					
Group	114.1	4	28.5	3.7	< 0.05
Session	50.5	2	25.2	9.2	< 0.05
Group*Session	9.3	8	1.3	0.4	ns

Groups: 100% Wheat ($n = 24$); Sorghum ($n = 21$); Wheat-soya ($n = 20$) Sorghum-soya ($n = 18$); Control ($n = 20$)

5.3.6 Effect of biscuit type x evaluation session (pre-exposure, post exposure and follow-up) on hedonic ratings of appearance, taste, smell and overall liking of biscuits

Two-way repeated measures ANOVA (Table 5.4) revealed that there was a significant interaction effect of biscuit type x evaluation session on hedonic ratings of the appearance [$F(6, 612) = 3.3; p \leq 0.05$], smell [$F(6, 612) = 5.3; p \leq 0.05$], taste [$F(6, 258) = 2.7; p \leq 0.05$], and overall liking [$F(6, 612) = 2.3; p \leq 0.05$] of biscuits. For this reason, significant main effects will not be discussed further. Liking of smell of sorghum-soya biscuits was significantly lower during the pre-exposure (4.8 ± 2.0) and follow-up session (4.7 ± 1.9) as compared to the post-exposure session (5.4 ± 1.7). There were no significant differences in liking of smell for 100 % sorghum biscuits at the pre-exposure, post-exposure and follow-up sessions (Table 5.5).

Table 5.4 shows that there was no change in liking of the appearance of sorghum-soya and wheat-soya biscuits over the three sessions (pre-exposure, post exposure and follow-up). The appearance of 100% wheat biscuits was liked better during the follow-up session (6.6 ± 1.9) compared to the post-exposure session but was equally liked during the pre-exposure session (Table 5.4). For sorghum-soya biscuits, the mean liking of taste score during the post-exposure session (4.8 ± 2.2) was higher than that of the pre-exposure session (4.0 ± 2.3). There were no changes in the liking of taste for 100% sorghum and wheat-based biscuits over the three evaluation sessions.

Results in table 5.5 also showed that sorghum-soya biscuits had significantly lower overall liking scores during the pre-exposure (4.0 ± 2.3) compared to the post exposure session (4.8 ± 2.1). For 100% wheat biscuits, highest overall liking scores were observed during the follow-up session (6.1 ± 1.9).

Table 5.4: Effect of biscuit type x session on the hedonic rating of smell, appearance, taste and overall liking of biscuits

Sources of variation	Sum of squares (ss)	Degrees of freedom (df)	Mean of squares (ms)	F value	p
<u>Appearance</u>					
Biscuit type	612.44	3	275.36	56.38	<0.001
Session	6.64	2	3.32	0.9	ns
Biscuit type*Session	40.33	6	6.72	3.28	<0.05 ^c
<u>Smell</u>					
Biscuit type	321.07	3	122.28	42.89	<0.001 ^a
Session	14.96	2	8.26	2.19	ns ^b
Biscuit type*Session	59.41	6	10.72	5.13	<0.001
<u>Taste</u>					
Biscuit type	276.18	3	108.96	20.46	<0.001
Session	53.25	2	32.1	5.74	<0.05
Biscuit type*Session	36.64	6	6.11	2.66	<0.05
<u>Overall liking</u>					
Biscuit type	359.93	3	133.84	32.38	<0.001
Session	28	2	16.61	2.71	ns
Biscuit type*Session	26.796	6	4.45	2.35	<0.05

Level of significance

(a) ns- not significant at $p > 0.05$

(b) Significant at $p < 0.001$

(c) Significant at $p \leq 0.05$

Table 5.5: The post-hoc of the interaction effect of the biscuit type x session

Biscuit type	Attribute	Session			p-value
		Pre	Post	Follow-up	
100% Wheat	<u>Appearance</u>	6.5 ^{ab} ±2.2	6.0 ^a ±1.9	6.6 ^b ±1.9	<0.05
100% Sorghum		4.5 ^{ab} ±2.3	4.9 ^a ±2.0	4.3 ^b ±2.1	<0.05
70:30Wheat:Soya		5.3 ^a ±2.0	5.2 ^a ±2.0	5.2 ^a ±2.0	ns
70:30Sorghum:Soya		4.9 ^a ±2.1	4.8 ^a ±2.1	4.4 ^a ±2.1	ns
100% Wheat	<u>Smell</u>	6.6 ^a ±1.8	5.9 ^b ±1.7	6.3 ^{ab} ±1.7	<0.05
100% Sorghum		5.1 ^{ab} ±2.1	5.4 ^a ±1.7	4.81 ^b ±2.0	<0.05
70:30Wheat:Soya		5.4 ^a ±2.0	5.6 ^a ±1.8	5.3 ^a ±1.8	ns
70:30Sorghum:Soya		4.8 ^a ±2.0	5.4 ^b ±1.7	4.7 ^a ±1.9	<0.05
100% Sorghum	<u>Taste</u>	4.2 ^a ±2.6	4.8 ^a ±2.1	4.4 ^a ±2.3	ns
70:30Wheat:Soya		4.7 ^a ±2.3	5.1 ^a ±2.1	5.1 ^a ±2.2	ns
70:30Sorghum:Soya		3.9 ^a ±2.5	4.8 ^b ±2.2	4.2 ^{ab} ±2.2	<0.05
100% Wheat		5.3 ^a ±2.2	5.3 ^a ±2.0	5.6 ^a ±2.2	ns
100% Wheat	<u>Overall liking</u>	5.5 ^a ±2.2	5.6 ^a ±1.8	6.1 ^b ±1.9	< 0.05
100% Sorghum		4.2 ^a ±2.4	4.6 ^a ±1.9	4.4 ^a ±2.1	ns
70:30Wheat:Soya		4.9 ^a ±2.1	5.0 ^a ±2.0	4.9 ^a ±2.1	ns
70:30Sorghum:Soya		4.0 ^a ±2.3	4.8 ^b ±2.1	4.5 ^{ab} ±2.1	< 0.05

¹Values are means SD. Means with different superscripts (^{abc}) in the same row, differ significantly $p \leq 0.05$
³Data shows means values of smell, taste and appearance of all biscuits as rated by all participants ($n = 103$) during the pre, post and follow-up tasting sessions

²Measurement of overall liking, smell, taste and appearance was done using a 9-point hedonic scale with points of 9=Like extremely, 8= Like very much, 7=Like Moderately, 6 Like Slightly, 5= Neither like or dislike, 4=Dislike slightly, 3= Dislike moderately, 2= Dislike very much, 1= Dislike extremely

5.3.7 Effect of evaluation session on the overall liking of all biscuits

Considering all consumers ($n = 103$), Table 5.6 shows that 100 % wheat biscuits were better appreciated in comparison to sorghum-soya or sorghum biscuits in all three evaluation sessions (pre-exposure, post-exposure and follow-up).

Table 5.6: Post hoc comparison of the mean overall liking ratings (\pm standard deviations) of each biscuit per each evaluation session as evaluated by consumers ($n = 103$).

<u>Biscuit Type</u>	Session		
	Pre	Post	Follow-up
100% Wheat	5.5 ^a \pm 2.2	5.6 ^a \pm 1.8	6.1 ^a \pm 1.9
100% Sorghum	4.2 ^b \pm 2.4	4.6 ^b \pm 1.9	4.4 ^b \pm 2.1
70:30Wheat:Soya	4.9 ^a \pm 2.1	5.0 ^b \pm 2.0	4.9 ^b \pm 2.1
70:30Sorghum:Soya	4.0 ^b \pm 2.3	4.6 ^b \pm 2.1	4.5 ^b \pm 2.1
p-value	<0.05	<0.05	<0.05

Means in the same column, with different superscripts (^{ab}), differ significantly $p \leq 0.05$.

Measurement of overall liking was done using a 9-point hedonic scale with points; 9=Like extremely, 8= Like very much, 7=Like moderately, 6 Like slightly, 5= Neither like or dislike, 4=Dislike slightly, 3= Dislike moderately, 2= Dislike very much, 1= Dislike extremely

5.3.8 Effect of evaluation session on overall liking of biscuits by the exposure groups and control group (not exposed to biscuits for 20 days)

The mean overall liking ratings for wheat, sorghum, sorghum-soya biscuits during the pre-exposure, post-exposure and follow-up sessions were similar ($p > 0.05$) between groups exposed to a biscuit type for 20 days and the control group (group not exposed to biscuits for 20 days) as shown in Table 5.7. However, the groups differed significantly, [$F(1, 38) = 5.99$; $p \leq 0.05$] with regards to overall liking of wheat-soya biscuits. Consumers in the control group liked the wheat-soya biscuits more than consumers in the group that was exposed to wheat-soya biscuits for 20 days.

Table 5.7: The effect of non-exposure or exposure to a biscuit type (exposure vs non-exposure group), session of evaluation (pre-exposure, post exposure and follow-up) and the interaction of these effects on overall liking of biscuits

Sources of variation	Sum of squares (ss)	Degrees of freedom (df)	Mean of squares (ms)	F value	p
<u>100% Wheat biscuit</u>					
Group ^b	4.6	1	4.6	0.58	ns ^a
Session	9.46	2	4.73	2.32	ns
Group*Session	2	2	1	0.49	ns
<u>100% Sorghum biscuit</u>					
Group	0.56	1	0.56	0.06	ns
Session	2.12	2	1.1	0.32	ns
Group *Session	2.22	2	1.11	0.34	ns
<u>70:30Wheat:Soya biscuit</u>					
Group	58.8	1	58.8	6	< 0.05
Session	6.17	2	3.03	1.38	ns
Group*Session	6.2	2	3.1	1.41	ns
<u>70:30Sorghum:Soya biscuit</u>					
Group	1.38	1	1.38	0.17	ns
Session	10	2	6.5	1.75	ns
Group*Session	2.4	2	1.55	0.42	ns

^bGroup (Exposure vs non-exposure)

Exposure groups: 100% Wheat ($n = 24$); Sorghum ($n = 21$); Wheat-soya ($n = 20$) Sorghum-soya ($n = 18$)

Non-exposure (control) group ($n=20$)

^ans – not significant at $p \leq 0.05$.

5.3.9 Effect of food neophobia propensity of participants (low-neophobia vs high neophobia) on the overall liking of each biscuit type during the pre-exposure, post-exposure and follow-up sessions

The internal reliability of the Food Neophobia Scale was found to be 0.71. A Cronbach's alpha score of at least 0.7 or higher is regarded as good (Wells and Wollack, 2003). The minimum neophobia score was 14 and the maximum was 58. Most consumers in the wheat-soya and non-exposure group had high food neophobic tendencies whilst most participants in the sorghum-soya and sorghum group had low-food neophobic tendencies (Figure 5.5).

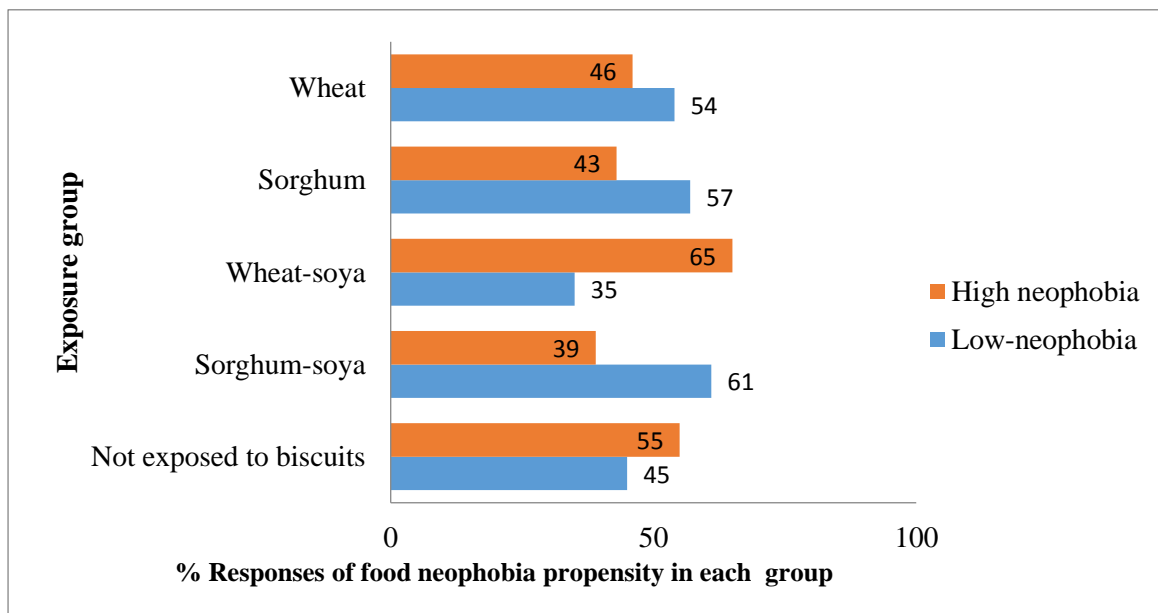


Figure 5.5: Distribution of percentages of consumers in the experimental groups that have high and low neophobia propensity. Exposure groups: 100% Wheat ($n = 24$); Sorghum ($n = 21$); Wheat-soya ($n = 20$)

Sorghum-soya ($n=18$); Non-exposure group ($n=20$)

High neophobia ($n= 52$); Low neophobia ($n= 51$)

5.3.10 Effect of consumers' food neophobia propensity on evaluation session

Table 5.8 shows that consumers' food neophobia propensity had no effect on the overall liking ratings of sorghum-soya biscuits during the pre-exposure, post-exposure and follow-up sessions [$F(2,179) = 1.2, p > 0.05$].

Table 5.8: Effect of consumers' food neophobia propensity x session (pre-exposure, post-exposure and follow-up session) on overall liking of biscuits

Sources of variation	Sum of squares (ss)	Degrees of freedom (df)	Mean of squares (ms)	F value	p
<u>100% Wheat biscuit</u>					
Group ^b	4.8	1	4.8	0.5	ns ^a
Session	20.1	2	11.4	5.9	< 0.05
Group*Session	4.7	2	2.7	1.3	ns
<u>100% Sorghum biscuit</u>					
Group	1.0	1	1.0	0.1	ns
Session	11.4	2	5.7	2.2	ns
Group *Session	8.1	2	4.6	1.6	ns
<u>70:30 Wheat:Soya biscuit</u>					
Group	5.9	1	5.9	0.7	ns
Session	5.4	2	2.7	1.1	ns
Group*Session	4.5	2	2.2	0.9	ns
<u>70:30 Sorghum:Soya biscuit</u>					
Group	6.4	1	6.4	0.7	ns
Session	50.6	2	28.6	9.5	< 0.05
Group*Session	6.4	2	3.6	1.2	ns

^bGroups (Low-neophobia vs High neophobia)

High neophobia ($n= 52$); Low neophobia ($n= 51$)

5.3.11 Distribution of consumers with high and low familiarity to sorghum in experimental groups

More participants (82 %) were familiar with sorghum, while 18 % were not familiar with sorghum (Figure 5.7). Figure 5.8 shows that in each experimental group the majority of participants were familiar with sorghum. For example, in the sorghum-soya group, 89 % indicated that they were familiar with sorghum.

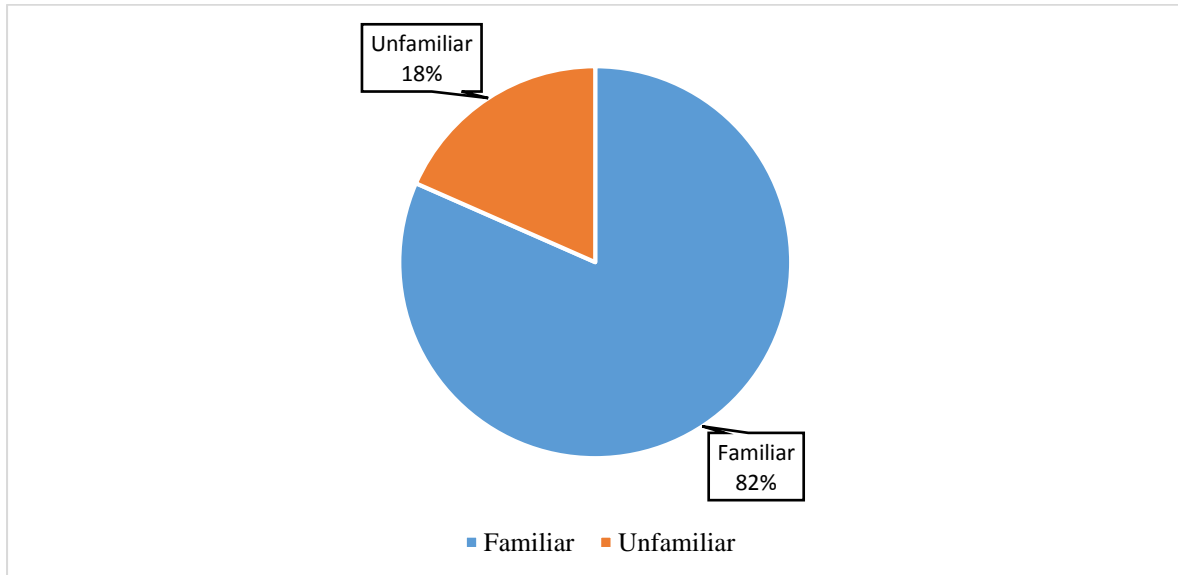


Figure 5.6 : Distribution of % of participants who were unfamiliar and familiar with sorghum (n= 103)

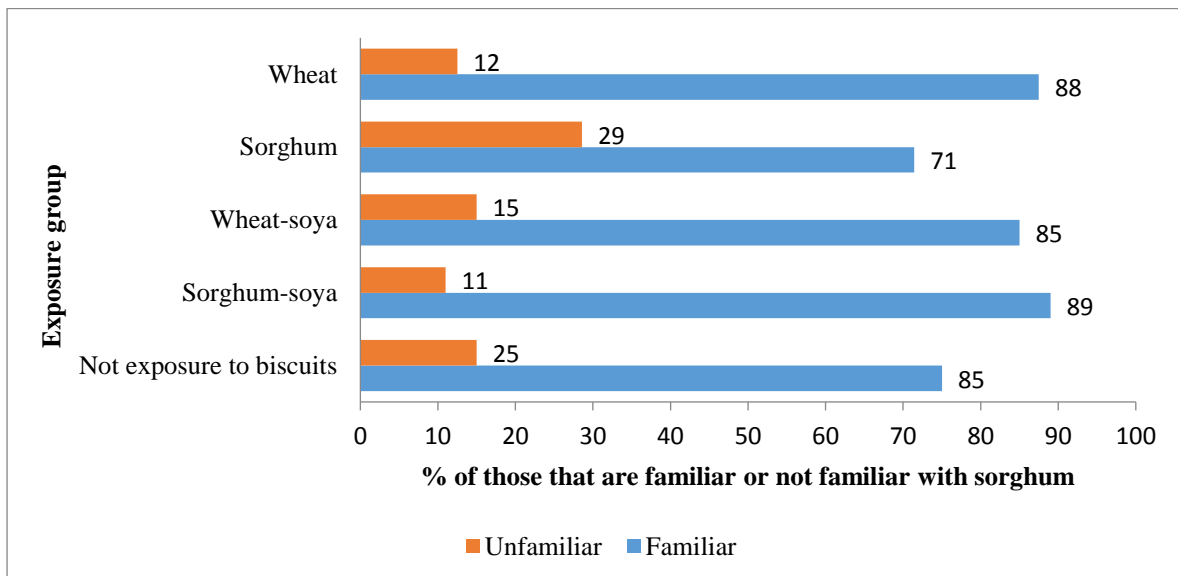


Figure 5.7 : Distribution of percentages of consumers in the experimental groups that are familiar or not familiar with sorghum. Exposure groups: 100% Wheat (n = 24); Sorghum (n = 21); Wheat-soya (n =20) Sorghum-soya (n=18); Non-exposure group (n=20)

5.3.12 The effect of consumers' familiarity and unfamiliarity with sorghum x evaluation session on overall liking of biscuits.

Table 5.9 is showing the results of the effect of consumers' familiarity and unfamiliarity with sorghum on the overall liking of all four biscuit types. Mean hedonic ratings of sorghum-soya biscuits for consumers that were familiar or not familiar with sorghum were not different, [$F=(2, 534.2) = 2.1; p > 0.05$]. There was no significant interaction between group (familiarity vs not familiar with sorghum) and evaluation session for sorghum biscuits: [$F= (2,527.1) = 0.9; p > 0.05$] nor for wheat biscuits [$F= (2,351) = 0.8; p > 0.05$].

Table 5.9: The effect of consumers' familiarity and unfamiliarity with sorghum x evaluation session on the overall liking of biscuits

Sources of variation	Sum of squares (ss)	Degrees of freedom (df)	Mean of squares (ms)	F value	p
<u>100% Wheat biscuit</u>					
Group ^b	7.1	1	7.1	0.8	ns ^a
Session	11.1	2	5.9	6.2	< 0.05
Group*Session	0.1	2	1.8	0.0	ns
<u>100% Sorghum biscuit</u>					
Group	0.5	1	0.5	0.0	ns
Session	2.5	2	2.5	0.8	ns
Group *Session	4.9	2	2.7	0.9	ns
<u>70:30Wheat:Soya biscuit</u>					
Group	11.9	1	11.9	1.6	ns
Session	4.4	2	2.3	0.9	ns
Group*Session	0.6	2	0.3	0.1	ns
<u>70:30Sorghum:Soya biscuit</u>					
Group	1.4	1	1.4	0.2	ns
Session	57.3	2	32.2	10.8	< 0.05
Group*Session	11	2	6.2	2.1	ns

^ans- not significant

^bGroup (Familiar vs non-familiar with sorghum)

Familiar with sorghum (n= 84); Not familiar with sorghum (n= 19)

5.3.13 Correlation between overall liking scores for biscuits during the exposure phase and consumers' boredom or enjoyment of the task

There was no significant correlation between overall liking ratings measured over 20 days for all biscuit types and consumers' perception of boredom and enjoyment with the task of evaluating biscuits for 20 days (Table 5.10). Boredom ratings were positively correlated with the overall liking scores of wheat-soya biscuits such that the more the consumers liked the biscuits, the more they found the task of evaluating biscuits for 20 days not boring. The enjoyment scores were not significantly correlated with overall liking of any biscuit type.

Table 5.10: Correlation coefficients (r) of overall liking of biscuits during the 20-day exposure phase and perception of boredom and enjoyment with the task

<u>Biscuit type</u>	Boredom	Enjoyment
100% Wheat	0.14	0.11
100% Sorghum	-0.06	0.21
70:30Wheat:Soya	0.59**	0.41
70:30Sorghum:Soya	0.21	0.28

Values in bold are significant

**correlation is significant at $p < 0.05$

Boredom scale 5 = not boring at all, 4 = slightly boring, 3 = moderately boring, 2 = very boring, 1 = extremely boring

Enjoyment scale 5 = extremely fun, 4 = very fun; 3 = moderately fun, 2 = slightly fun, 1 = not fun at all

5.3.14 Effect of repeated exposure to biscuits on purchase intent

The ratings for the intent to purchase sorghum-soya biscuits were similar on days 1, 10 and 20 (Figure 5.9). Consumers in the group that was exposed to wheat biscuits for 20 days also rated intent to purchase wheat biscuits similarly on days 1, 10 and 20 of the repeated exposure phase. The mean ratings for intent to purchase both sorghum and wheat-soya biscuits on day 1 were higher than on day 10), but the same on day 20.

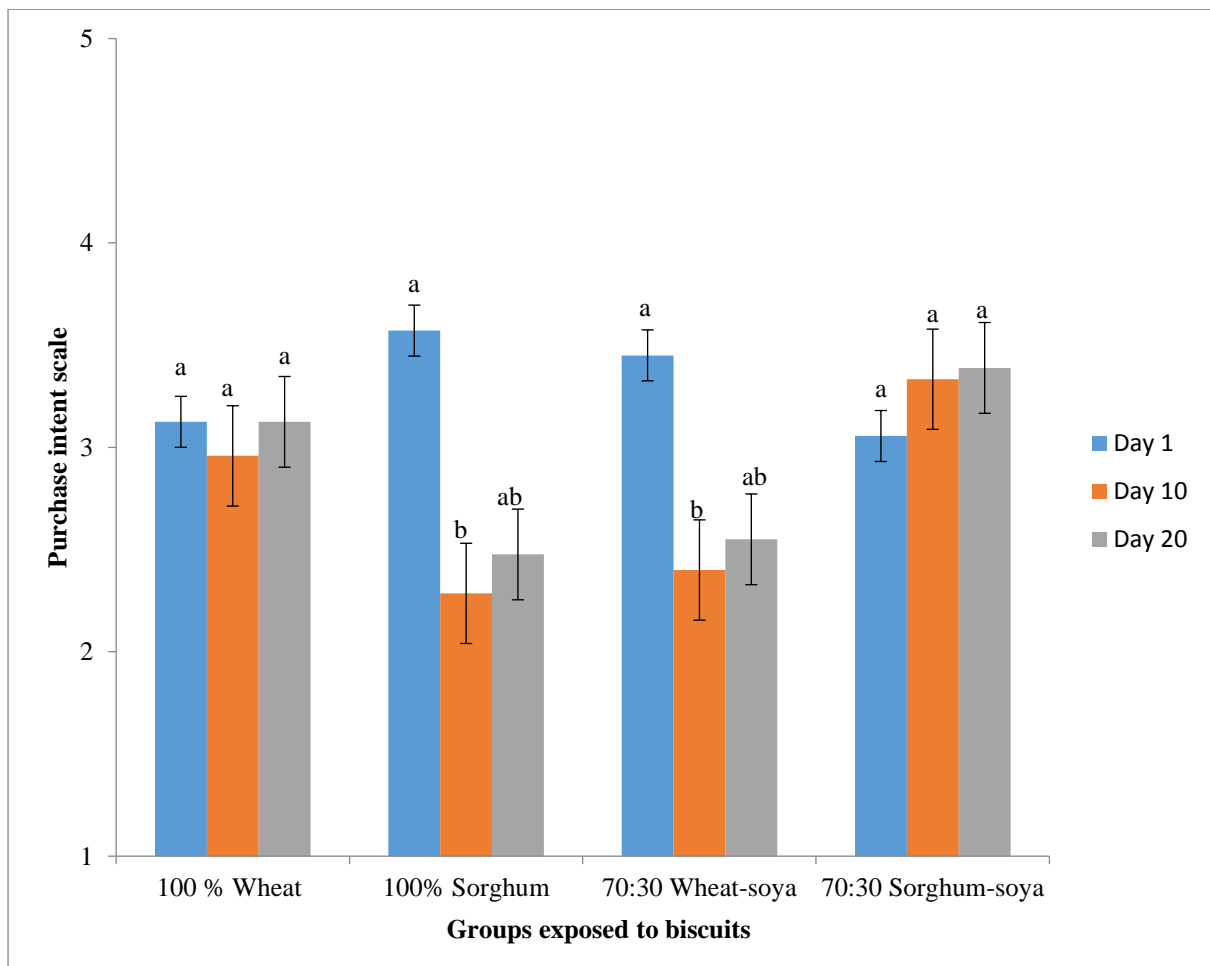


Figure 5.8: The mean (\pm standard deviation) purchase intent ratings for specific biscuits as assessed by consumers that were exposed to that biscuit type on three different occasions. Purchase intent rating scale 1 = Definitely would not buy, 2 = Probably would not buy, 3 = Might or might not buy, 4 = Probably would buy, 5 = Definitely would buy. Bars represent the mean purchase intent scores. Bars with different superscripts show that means differ significantly at $p \leq 0.05$.

Exposure groups: 100% Wheat ($n = 24$); Sorghum ($n = 21$); Wheat-soya ($n = 20$) Sorghum-soya ($n = 18$)

6 Discussion

Since the effect of repeated exposure on sorghum-soya or sorghum only biscuits was the main interest of the study, the discussion will focus more on these biscuits. Sorghum-soya and sorghum biscuits were regarded as unfamiliar or novel biscuits. This was so because when this study was conducted there were no sorghum or sorghum-soya biscuits available on the South African commercial market (*personal observation*). The first part focuses on discussing the hedonic ratings of sorghum-soya, sorghum, wheat-soya and wheat biscuits when results of the day 0 (pre-exposure) were compared to that of 20-day repeated exposure phase, post exposure (day 23) and follow-up sessions (day 34) for each exposure group. It was hypothesised that the liking for unfamiliar biscuits would increase over time while the liking for familiar wheat biscuits would decrease or remain constant. Results showed that there was a positive change in liking of unfamiliar biscuits but only on some days of the 20 days repeated exposure phase. The findings obtained support the mere-exposure theory of Zajonc (1968) which states that familiarisation leads to increased liking (Otis, 1984). It clearly shows that sensory experience (time and repeated consumption) did have a positive effect on hedonic value of unfamiliar biscuits during the exposure period. However, this positive hedonic adjustment did not last long after the regular forced consumption phase since no positive hedonic adjustment was noticed during the post-exposure (day 23) and follow-up sessions (day 34). The results may be explained using the theory of Walker (1980) which claims that exposure to very complex stimuli causes a reduction in complexity resulting in an increase in liking of the stimuli (Köster and Mojet, 2012). Hence, it is possible that the unfamiliar biscuits were too complex for participants in the beginning (pre-exposure session) but that the complexity reduced over the exposure period causing an increase in liking on some of the days of the 20-day exposure phase. The consumers in the sorghum and sorghum-soya groups particularly commented that the biscuits tasted better with time (repeated consumption).

Since significant increases in liking of unfamiliar biscuits were noticed on some days of the 20-day exposure phase, it was expected that at least an increase in liking would be recorded during the post-exposure and follow-up sessions. The reason why positive hedonic adjustment during the follow-up or post-exposure sessions was not found could be related to the time factor. Maybe 20 consumption times were not enough to cause any permanent significant changes in liking. Thus far, there is no standard method for repeated measure studies that have been developed hence it is difficult to ascertain the exact period that can cause change in liking for consumers.

On the other hand, the significant increases in liking of unfamiliar biscuits noticed in this study could be associated with the issue of the meal context (i.e. whether the biscuits were eaten alone or together with other foods) (Hoek et al., 2013). Some studies have established that sensory exposure to a single product (i.e. eaten alone) differs from that of the product consumed in combination with other foods (Rozin and Tuorila, 1993, Hoek et al., 2013). During the 20-day exposure phase the biscuits were consumed at home hence there is a likelihood that these were accompanied with other foods such as hot beverages (e.g. tea). Therefore, there is a possibility that the drinks or beverages or other products that were consumed together with the biscuits could have masked the complex flavour and taste of biscuits such that the complex or specific sensory attributes present in the biscuits were not perceived. In agreement to this notion, Hoek et al. (2013) showed that there was a difference in liking of chicken when it was consumed alone compared to as part of a meal context. Some consumers in the sorghum biscuits experimental group indicated in their comments that the biscuits “taste better with coffee” (Figure 10.2).

As expected, a decrease in the liking for 100% wheat biscuits was noticed on day 1 of the exposure phase for the group that was exposed to wheat biscuits for 20 days. This shows that the wheat biscuits were indeed not complex and not novel to consumers because the results support the predictions of the Dember and Earl (1957) which states that exposure to a familiar or less complex stimuli will lead to decrease or no change in liking.

The expectation was that participants exposed to novel biscuits would prefer these biscuits more than those in non-exposure group during the post-exposure and follow-up session. This is so because, it was anticipated that those who were in the exposure group would overcome the complexity of the novel biscuits through repeated consumption leading to an increase in liking while those who were only exposed to novel biscuits once during the pre-exposure session would not prefer them as much as the exposure group because they did not get to learn to appreciate the stimulus (novel biscuits). However due to some drop outs that occurred during the study, the group sizes were very limited hence this could have statistically affected the results.

Liking of the appearance of the composite biscuits remained constant over the three tasting sessions but the same was not found for the 100 % grain biscuits. The changes in liking for appearance of sorghum biscuits could have been associated with their colour. Sorghum biscuits were characterised with a dark brown colour and in the beginning (pre-exposure) participants

could be associated with the dark brown colour with chocolate flavour, thus higher hedonic values were recorded in the pre-exposure and post exposure sessions as compared to the follow-up session.

The smell of sorghum-soya biscuits was liked significantly more during the post-exposure session compared to the pre-exposure and follow-up session. The decrease in liking during the follow-up session could be attributed to product boredom. Since the follow-up session was the last exposure session there is a possibility that continuous evaluation of biscuits might have gradually triggered a boredom feeling which led to a decrease in liking noticed already when participants smelled the biscuits.

The taste hedonics of all biscuits except for sorghum-soya biscuits remained stable over the three tasting sessions. However, for sorghum-soya biscuits the average liking was initially low but increased by 23 % during the post exposure session. The initial low liking could have occurred because initially the participants might have found the biscuits to be very complex for them since sorghum containing biscuits have been characterised with undesirable gritty residue, grainy texture whereas soya biscuits have been identified to have negative flavour attributes described as grassy, painty and cardboardy (Boge et al., 2009, Chiremba et al., 2009, Serrem, 2010). The participants could have experienced complexity of sorghum biscuits over time. These results are in full accordance with the predictions of the complexity-pacer theory of Dember and Earl (1957) which proposed that when exposed to stimuli of a higher complexity than an individual optimal level of complexity a shift occurs in the upwards direction while exposure to a less complex stimulus causes the optimal level to remain unchanged (Köster and Mojet, 2006). Research by Kinnear and de Kock (2011) also documented that the hedonic scores of flavoured sport drinks with different acidulants that were perceived as less familiar and more complex, increased with exposure.

The overall liking of sorghum-soya biscuits was more preferred during the post-exposure session. These results are in line with the claims of the arousal potential theory proposed by Berlyne (1970). The theory explains that initially the subject is in a state of conflict because of being uncertain about the characteristics of the stimuli (stimuli property) and curiosity or fear (individual characteristics) (Lévy and Köster, 1999). The theory further states that during exposure the collative stimuli properties such as novelty and complexity with high arousal potential eventually diminishes causing a shift towards the optimum level of arousal which leads to increased liking of the stimuli (Köster and Mojet, 2006).

The results showed that the hedonic responses of the experimental groups that were exposed to 100% wheat, sorghum-soya and 100% sorghum biscuits, respectively for 20 days did not differ from the group that did not receive biscuits to consume during this period. Considering the mere-exposure effects, the assumption was that there would be a familiarity-liking relationship such that the hedonic scores for biscuits during the post and follow-up sessions for the groups that were exposed to the unfamiliar biscuits (sorghum-soya and sorghum) would be higher than that of the control group. For the group repeatedly consuming 100% wheat biscuits it was hypothesised that the mean hedonic rating would be lower than that of the control group. The fact that repeated consumption did not cause any effect on overall liking of sorghum-soya and 100% sorghum biscuits, confirms that even though 71 % participants indicated that they were familiar with sorghum, this factor did not have a strong influence on liking of the biscuits. These results are in contrast to findings from various studies that have highlighted the use of repeated exposure as a strategy of increasing liking in many unfamiliar foods such as meat substitutes, vegetables and drinks (Hoek et al., 2013, Lakkakula et al., 2010, Sulmont-Rossé et al., 2008). A study by Costa et al. (2014) indicated that there was a correlation between the number of exposure sessions and the increase in acceptance of goat-milk yoghurt by exposure groups. The authors further recommended that increasing the number of exposure sessions can be used as a strategy to increase liking of goat-milk based products.

The control group (non-exposure group) rated wheat-soya biscuits higher than the exposure group that was exposed to wheat-soya biscuits for 20 days. It is uncertain why these results were found. Sulmont-Rossé et al. (2008) noted that there are two opposing effects that are likely to occur due to exposure, which include boredom or an uncertainty resolving effect. The boredom effect has been attributed to product irritation and in this case, it is probable that the product irritation occurred to the group that was exposed to wheat-soya biscuits for 20 days. It is also possible that some personal characteristics could have played a role in the acceptance of the biscuits during exposure. Variety seeking behaviour is an example of a personal attribute, that affect hedonic ratings of food during exposure especially when participants are being exposed to the same type of food (Chung and Vickers, 2007b). This is so because usually humans do not want to be limited to one food choice instead they want to fulfil their variety needs by having a choice between a wide selection of food products (Hoek et al., 2013). Moreover, the 20-day exposure phase was measured in a non-choice situation hence there is a probability that if the participant in the exposure group had high variety seeking tendencies, they got tired of tasting the same product, which caused low hedonic ratings of wheat-soya

biscuits. In another repeated exposure experiment Zandstra et al. (2000) found that there was a smaller decrease in liking when consumers were given the option to choose among three flavours of meat sauces than in a no-choice situation during repeated exposure testing. Hoek et al. (2013) suggested that product boredom can be lessened by offering a variety of food to accompany the meat substitutes.

The assessment of consumers' intent to purchase a product is very critical in identifying the market potential or the forecast for purchase of a product (Van Kleef et al., 2005). Repeated exposure to sorghum and wheat-soya biscuits had an effect on the consumers' intent to purchase the biscuits. The intent to purchase wheat-soya or sorghum biscuits decreased on day 10 than on day 1 but the rating was similar to day 20. It is possible that in the beginning of the exposure phase (day 1) the biscuits were complex to participants and this caused them to become curious about the product hence the intent to purchase was high but once they became more familiar with the biscuits their intent to purchase the biscuits decreased.

Certain personal attributes in individuals influence their food acceptance (Hoek et al., 2013). Indeed, food neophobia is a personal attribute that could be related to the causes of flops of new products entering the market (Damsbo-Svendsen et al., 2017). However, several studies have established that food neophobia in individuals can be reduced through extended sensory exposure to that specific novel food (Anzman-Frasca et al., 2012, Wardle et al., 2003b, Lakkakula et al., 2010). The results from this study showed that only 48 % of participants were neophobic. In contrast to expectations it was found that, neophobic behaviour did not have a significant effect on overall liking of the novel sorghum-based biscuits. This is contrary to the suggested evidence that claims that food neophobics react negatively towards new foods (Pliner and Hobden, 1992). In contrast to findings of this study, Arvola et al. (1999) reported that pleasantness ratings of neophobics for unfamiliar cheeses were lower than neophilics. In the present study, it is probable that although these biscuits were novel in the sense that they were not yet available in the market, the participants were actually familiar with the main ingredients, which are sorghum and soya. Moreover, 81.4 % of the participants indicated that they are familiar with sorghum. Thus, the sorghum or sorghum-soya biscuits might not have been too complex or highly novel to consumers such that they did not have any uncertainty issues or negative attitude towards the biscuits. There is also a likelihood that some participants were highly familiarised with soya because a soya consumption study conducted in South Africa by Van De Merwe et al. (2013) indicated that soya flour and other soya products are

used as an ingredient in various food products such as bakery, cereal, beverage and meat products.

The product familiarization process involves learning and experiencing a product such that the novelty and uncertainty perceptions about the product are eliminated over time (Giacalone et al., 2014). Given the fact that, sorghum is an underutilised staple cereal (Orr et al., 2016), it was important to determine whether participants were familiar with it or not. Despite the fact that, 81.4 % participants indicated that they were familiar with sorghum, this did not have any effect on the overall liking of all biscuit formulations. The assumption was that the participants who were familiar with sorghum would like sorghum-based biscuits more than the ones who were not familiar with sorghum. The above-mentioned assumption was not observed probably due to the fact that although the majority indicated that they were familiar with sorghum, there is a high possibility that they were unfamiliar with novel products from sorghum such as these biscuits. In addition, familiarity would not have caused any change in liking in this present study because the findings from the food choice questionnaire revealed that familiarity was not the most important motive they consider when making food choices. Instead, participants indicated that their food choices are mainly influenced by sensory appeal. In a study by Prescott et al. (2002) consumers from Japan, Taiwan, Malaysia, and New Zealand also indicated that familiarity was the lowest factor that influenced their food choices.

There are two kinds of boredom that have been associated with low product acceptance which are product boredom and experimental or task boredom (Sulmont-Rossé et al., 2008). Experimental boredom occurs when consumers are generally bored with the task of repetitively tasting the same product while product boredom is the loss of pleasure in the product (Sulmont-Rossé et al., 2008, Zandstra et al., 2000). This research study focused on experimental boredom with the aim of determining whether there was an association with hedonic ratings. The task boredom was not significantly correlated with the overall liking of sorghum-soya, 100% wheat and sorghum biscuits. The findings show that for the consumers in the groups that were exposed to sorghum-soya, 100% wheat or sorghum biscuits the exposure experience did not trigger irritation (boredom). However, there was a strong positive significant correlation between the overall liking of wheat-soya biscuits and experimental boredom. This reveals that wheat-soya biscuits might have been more susceptible to product boredom. A study by Stubenitsky et al. (1999) revealed that the boredom ratings of sausages and chocolates during exposure were related to the experimental procedure and not sensory attributes of the products. In another study, Sulmont-Rossé et al. (2008) also observed that the experimental boredom

effect played a role in the disliking of uncommon drinks. Correlation data also indicated there was no significant relationship between consumers' enjoyment of the experience and the overall liking ratings of all biscuits. These results are positive because consumers' feelings towards the repeated exposure task should not influence hedonic ratings. Instead, the hedonic ratings should be led by the consumers' sensory perceptions about the test samples.

6.1.1 Conclusions

Sorghum and sorghum-soya biscuits are not liked as much as more familiar wheat biscuits. However, since the experiment revealed trends of positive hedonic adjustment when repeatedly consuming sorghum-soya biscuits, it is predicted that consumers that are keen to try the novel biscuits will grow to like them more when they eat them repeatedly. Familiarity with sorghum and food neophobia tendencies did not influence hedonic ratings for the sorghum-soya biscuits. This is positive as it shows that the products in the current form as biscuit are familiar enough to be acceptable to most consumers, neophobics and neophilics. The outcomes of this study show that repeated exposure can be used as a strategy for predicting long-term preferences and potential acceptance of sorghum-soya biscuits.

7 GENERAL DISCUSSION

This chapter will comprise of three main sections. Firstly, the materials and methodology of the experimental work will be critically reviewed. Secondly, this chapter will critically discuss the strengths and weaknesses of the experimental design including the questions asked during the survey. The practical challenges of conducting repeated exposure sensory evaluation are discussed. A tabulated summary of the findings from the repeated exposure consumer sensory evaluation will be given. A brief summary on the way forward and practical consequences of this study will also be discussed.

7.1 Critical review: Raw materials and baking procedure

Ideally, biscuits from this study were meant to be made from basic low-cost ingredients. Sorghum flour was used in this study to bake biscuits because sorghum is a basic traditional staple that is readily available in many regions of sub-Saharan Africa (Proietti et al., 2015). However, the main disadvantage is that commercial sorghum flour is pricey. The commercial price of sorghum flour is relatively higher than that of wheat flour (*personal observation*).

The unusual scone-like appearance of the wheat biscuits could have negatively affected the appearance of the biscuits. The greater thickness of wheat biscuits could have been avoided if sodium metabisulphite was added to the wheat dough. Sodium metabisulphite is popularly used for baking wheat biscuits in the industry because it facilitates the breakage of disulphide bonds in the gluten network (Ribera et al., 2001). In addition, the appearance of the biscuits could also have been affected with the elliptical shape that developed due to extensive dough shrinkage (*personal observation*).

The amount of water used for the four biscuit formulations was different. Soya containing doughs required higher water content during dough formation as compared to other doughs. The addition of the soya flour caused the dough to be firm and unworkable. The possible reason for this is that soya globulin protein are water soluble (Nehete et al., 2013), thus more water was required for soya based doughs. Conversely, the 100% sorghum dough was sticky and required less water compared to the wheat-based doughs this was probably due to the hydrophobic nature of sorghum proteins (de Mesa Stonestreet, 2011).

In this study, the creaming method was not used during the baking of the biscuits (Pareyt and Delcour, 2008). Instead, all dry ingredients were mixed followed by the addition of wet ingredients. Researchers have discouraged the use of non-creaming method during baking

biscuits as it impacts on biscuit hardness (Pareyt and Delcour, 2008, Manley, 2011). Therefore, the textural quality of the biscuits could have been better if the creaming method was used during preparation of the biscuits because during creaming the air and moisture are trapped into the mixture (Pareyt and Delcour, 2008).

A large quantity of the wheat-soya composite biscuits could not be used for the study because they were broken (*personal observation*) and this was observed during packaging and storage of the biscuits. It would have been very useful to analyse the rheological properties of the dough in order to determine the causes of fragility of the biscuits.

Approximately 4500 biscuits were needed for the repeated exposure sensory evaluation study. Although the quantity of the biscuits needed was huge for this study, the baking was manageable because the biscuits were baked in a facility with industrial baking equipment. This made the baking process fast and efficient such that all the biscuits were baked in 5 days. However, the process could have been much faster if the dough cutting process was not done manually.

Many researchers have reported that sorghum dough is very sticky and difficult to handle manually (Kulamarva et al., 2009, Bansal et al., 2012, Ratnavathi and Patil, 2013). In this study, the handling was much easier because of the industrial baking machinery that was used during the preparation process. The major advantage of using baking machinery is that biscuits with a uniform dough thickness and structure were possible.

While the use of table sugar was economical for biscuit production, the physical and surface appearance of biscuits should be taken into consideration. Pareyt and Delcour (2008) stated that large sugar particles cause grittiness in biscuits because large sugar particles do not readily dissolve in the dough as compared to fine particle sugar. Additionally, the large particles also limit the biscuit spreading (Manley, 2011). Therefore, the use of finely granulated sugar such as castor sugar could have reduced the grittiness and surface cracking of the sorghum-based biscuits.

The functions of fats in biscuit making generally includes determining the texture and imparting flavour (Manley, 2000). Sunflower cooking oil was used for baking the biscuits. A few studies have demonstrated that the use of oil contributes to biscuit hardness because oil cannot retain entrapped air (Jacob and Leelavathi, 2007, Manley, 2011). Research by Jacob and Leelavathi (2007) revealed that biscuits with oil were harder than those made with shortening. It would have been advantageous to compare the use of sunflower oil and

shortening for biscuit baking during the trial phase to compare the texture and flavour of the biscuits. This was important because consumers indicated that the biscuits were hard maybe the use of a shortening could improve the texture of the biscuits

Analysis of the cost of the biscuits is very important because it gives an indication of the expected price of the biscuits. Participants could have been asked about the amount they are willing to pay for each biscuit. This would have provided a comparison between the actual cost of product and the price that consumers expect to pay. The information could be very useful for commercialisation purposes because it gives the manufacturer a guided direction of the pricing of the product.

The biscuits for the survey were packaged in sealed plastic bags and put in closed 25 litre buckets which were stored in a freezer for a period of 4 months. The prolonged storage of the biscuits in the freezer might have affected the sensory quality of the biscuits. Cauvain (2017) reported that when biscuits are frozen the available water in the biscuits expands and it forms ice crystals these crystals might cause cracking of the biscuits. Therefore, this could have been the cause of broken biscuits noticed during storage.

7.2 Critical review: Analytical methods

7.2.1 Instrumental colour analysis

Colour is a very important attribute that is used for quality assessment of food products by consumers (Granato et al., 2010). For that reason, the main aim of the analysis of colour is to determine whether a relationship exists between consumer acceptance and colour of food. The instrumental colour measurement of the biscuits was done using a Minolta CR-300 (Japan) tristimulus colorimeter. The main advantage is that the measurement of the colorimeter is directly associated the colour perception of a human (Pathare et al., 2013). Other advantages of the method are that it is fast and non-destructive to the food product. As mentioned earlier colour of food can influence consumer acceptability, it was therefore would have been useful to correlate the instrumental data and subjective results from the consumer sensory evaluation to determine whether there was a relationship between the colour and the liking for appearance of biscuits. Dovi et al. (2018) positively correlated the L^* and b^* values of wheat biscuits with the overall liking of the biscuits. The colour properties of the flours used to bake the biscuits were not measured. This should for comparison of the colour of the flours and the biscuits.

7.2.2 Instrumental texture analysis

The texture analysis of the biscuits was done to assess the textural properties of the biscuits. When analysing the texture of the biscuits using the EZ-Test analyser (Model EZ-L, Shimadzu, Tokyo, Japan) each biscuit is compressed at least twice and the mechanical properties of the food recorded in terms of graphs, force, deformation and time (Szczesniak, 2002). The main advantage of the instrumental texture methods is that they are rapid and the measurement gives results that are precise and reproducible while textural results from panellist can be highly variable (Barrett et al., 2010, Singham et al., 2015). However, the direct comparison of the texture values obtained from the measurements was problematic because the sorghum and wheat biscuits differed in thickness. For comparison purposes when analysing texture with a 3-point bend rig, all the materials to be tested must have approximately the same thickness. This is so because a thick intrinsically weak material may appear to stronger than a thin intrinsically strong material and vice versa (Taylor, J.RN. 2018, personal communication, 29 August). Therefore, it was meaningless to compare stress, strain and hardness values of the biscuits because of the differences in thickness.

7.3 Critical review: Experimental design

The biscuits developed in this study have been recommended by Serrem et al. (2011) as complementary food for alleviating protein-malnutrition disease among young children. As such, the initial target group of participants for the present study was children aged between 8 to 12 years. Therefore, the participants used for this present study were young adults (college students and workers) aged between 18 to 26 years old. This target group was also perfect for the study because the biscuits are nutritious on-the-go snacks that provides high energy and protein to young adults.

The questionnaire for survey was programmed using sensory evaluation software called Compusense cloud® (Compusense, Ontario, Canada). The questionnaire was distributed online and this was very convenient for the investigators as well as participants because paper-based questionnaires can be a lot of work for the investigator because the data will need to be entered manually for statistical analysis. Since a lot of the sessions were done at home, this also minimised the risk of participants losing the questionnaires during the course of the survey.

The participants accessed the questionnaire by login to a URL web page using their username and password. However, there are two main challenges that participants faced regarding the accessibility of the questionnaire. Firstly, some of them could not remember their password even though their password was written on the biscuit calendars. This challenge could have

been avoided if the participants chose their own preferred username and password. Secondly, the fact that the questionnaire was online led to some of the participants complaining that they did not have continuous access to the internet or lacked data hence it affected their completion of the survey. However the online questionnaire was highly advantageous to the investigator because the results were automatically retrieved from excel, capturing result manually could have caused a lot of mistakes.

The participants were given calendars with biscuits that were attached to the dates that they were supposed to complete the survey. This helped a lot because it served as a reminder to the participants and no one was confused with the issue of the tasting dates and the quantities of biscuits to be eaten per day. However, the major drawback was that giving the participants all the biscuits for the 20-day exposure phase caused a huge drop out of participants ($n = 52$) due to the fact that some even forgot about the survey. Instead, the participants could have been given the biscuits after every 5 days, this could have allowed the investigator to keep in touch with the participants during the survey.

The testing conditions can influence the outcome of the test (Boutrolle et al., 2007). Köster and Mojet (2007) suggested that home use test offer better results because the task conducted under a realistic environment. In this study, the repeated consumption phase of the study was conducted at home. This was done with the aim of allowing participants to eat the biscuits under unrestricted conditions that permitted them to use the product under day-to-day settings. While the home use-testing environment offers natural tasting conditions, some drawbacks can significantly affect the results of the study. For example, the test is uncontrolled and the investigator does not know whether the participants really consumed the products or not. Moreover, the investigator will not be present to explain to the participant in-case they have something that they do not understand.

The pre-exposure and follow-up sessions were done at a central location while the other tests were done at home. Taking into account that the test environment can have an effect on the results (Boutrolle et al., 2007), the different test conditions could have introduced a source of variation to the results of the consumer sensory evaluation. For example, another study by Boutrolle et al. (2005) observed that products that were tested under home use settings had higher hedonic ratings than those tested under central location settings.

Repeated exposure studies have been encouraged for better prediction of long-term acceptance as well as promoting liking of novel foods (Anzman-Frasca, 2012, Chung and Vickers, 2007a).

Repeated exposure tests have been done over days or several weeks. Ghawi et al. (2014) conducted a repeated exposure study on reduced salt soup and they found that the liking of standard soup and low salt soup remained constant over time, whereas an increased liking was noticed in low salt soup with herbs and spices. When Hetherington et al. (2000) exposed consumers to chocolate over a period of 22 days, it was indicated that there was a decrease in pleasantness and desire to consume the chocolates. For this present study, participants were exposed to biscuits for a period of 20 days and liking for sorghum-soya biscuits was higher compared to the pre-exposure session. Researchers have conducted repeated exposure studies using different lengths of time. It might be necessary for researchers to develop a standard test method for repeated exposure sensory evaluation with a specific period that the exposure studies should be conducted. This is beneficial for direct and accurate comparison of the results of repeated exposure studies from other researchers.

The experimental design was designed in such a way that during the 20-day exposure phase the participants would eat one biscuit per day for 20 days and all 20 biscuits were from the same biscuit formulation. The participants were however not informed about it but this could have caused a direct decrease in the overall liking of the biscuits due to monotony. Hetherington et al. (2000) mentioned that frequent exposure to the same type of food leads to monotony. A crossover design could have been better because each participant would have been repeatedly exposed to all four biscuit formulations and the chances of product boredom or monotony would have been minimised.

7.4 Critical review: Survey questions

Several studies have reported on the relationship between food acceptance and perceived complexity. For example, the theories of food choice development by Dember and Earl (1957) and Berlyne (1967) have emphasised on perceived complexity as a collative property that plays a major role in acceptance of food during exposure (Giacalone et al., 2014). In this present study, no attention was paid towards the development of a question related to the complexity of the biscuits. For example, participants could be asked which biscuits contained unusual flavours, aroma or taste. This could have helped in better interpretation of the results and it could have provided insights on whether complexity did play a role in the liking of the biscuits. For instance, Lévy et al. (2006) measured perceived complexity of uncommon drinks by asking participants whether the drinks were made with a “single flavour/ composed of a mixture of many flavours”. Their results showed that exposure to complex drinks lead to an increase in

liking over time. They found strong evidence that their results support the claims of the theory of Dember and Earl (1957).

Familiarity is also another collative property, which has to do with previous sensory experience with the product (Giacalone et al., 2014). In this study, the participants were asked whether they were familiar with sorghum and they answered yes or no to the question. This question was not sufficient to elaborate familiarity. Firstly, it did not take into consideration the frequency to which the participant has encountered the product. Secondly, it did not address if this familiarity meant product knowledge only or familiarity that has to do with the product sensory experience.

Participants were questioned about the factors that influence their food choices and this was done using the standard food choice questionnaire designed by Steptoe et al. (1995). Assessment of factors influencing food choices gave a clear indication of the factors that governed the acceptance of the biscuits during this study. The standard food neophobia questionnaire designed Pliner and Hobden (1992) was also used to evaluate food neophobic behaviour in participants. The advantages of using standard questionnaires are that it is validated reliable instrument used to measure food neophobia in humans and it permits easy comparison of results with other sources in literature.

The main goal of any food manufacturing organisation is to produce food products that meet consumers' needs and wants (Moskowitz et al., 2012). There were acceptability questions asked during the survey however, these questions might not have addressed everything that the consumers thought or felt about the product or the exposure experience. There was a comment section provided on each questionnaire on all the exposure days, this section was inserted in order to accommodate consumers' opinions and suggestions. Many opinions and suggestions were given by consumers, this gave the researcher insights on what consumers thought about the product. This information given by the participants is very important because it gives the product developer ideas on how to optimise the product and what to improve in terms of the experimental design. For example, from the comments it is clear that for the sorghum-soya biscuits the optimization process should be focused on the texture and sweetness because most consumers in the sorghum-soya experimental group indicated the frequent terms used to describe were dry, hard, not-sweet-enough and grainy (granular).

Table 7.1: Summary of the effect of repeated exposure to sorghum-soya biscuits on consumers' acceptance

Objective	Findings	Possible explanation
Effect of repeated consumption on the overall liking of biscuits by each experimental group that participated in the 20-day exposure phase.	The overall liking for sorghum-soya biscuits was higher on days 2, 3, 5, 9, 13, 15 and 17 of the exposure phase compared to the baseline (pre-exposure). There was no change in liking among the post and follow-up and pre-exposure session.	Initially, the collative properties of sorghum-soya biscuits which are novelty and complexity induced negative hedonic response but through familiarity consumers got over the complexity or novelty of the biscuits and their appreciation of the product increased (Lévy et al., 2006).
To determine the effect of evaluation session on the overall liking of sorghum-soya biscuits	Sorghum-soya biscuits were more preferred during the post-exposure session than the pre-exposure session.	Initially the consumers were uncertain about the stimulus (sorghum-soya biscuits) identity but after the initial trial the appreciation increased because consumers got a chance to resolve any uncertainty issues they had regarding the stimulus (Sulmont-Rossé et al., 2008)
To assess whether repeated exposure had an effect on overall liking of sorghum-soya biscuits (sorghum-soya exposure group vs control group (non-exposure group))	The liking for sorghum-soya biscuits was similar during the pre, post and follow-up sessions between the group that was exposed to sorghum-soya biscuits for 20 days and the group that did not take part in the 20-day exposure phase.	The 20-day exposure phase might not have been sufficient to cause a permanent significant change in liking thus the rating of the exposure and non-exposure group was not significantly different.

Table 7.2: Summary of the effect of repeated exposure to sorghum-soya biscuits on consumers' acceptance (continued)

Objective	Findings	Possible explanation
To assess whether consumers' food neophobia propensities had an effect on the ratings of sorghum-soya biscuits during the pre-exposure, post-exposure and follow-up sessions.	Consumers' food neophobia propensity did not have any effect on liking of sorghum soya biscuits.	The high neophobic individuals did not find the properties of sorghum-soya to be too complex for them. Moreover, 81.4 % of the participants indicated that they were familiar with sorghum.
To determine whether familiarity had an effect on the overall liking ratings for sorghum-soya biscuits as measured at the beginning of the experiment (pre-exposure session).	Familiarity with sorghum did not have a significant effect on the liking of the sorghum-soya biscuits during the baseline (pre-exposure session).	Consumers in this study indicated that familiarity is a factor that least influences their food choices.
To determine whether there was a correlation between the liking scores of sorghum-soya biscuits and the boredom and/or enjoyment of the experience of participating in the repeated exposure biscuit tasting experience.	There were no significant correlations between the liking scores of sorghum-soya biscuits and the consumers' enjoyment and/or boredom of the experience of participating in the repeated exposure project.	The consumers in the sorghum-soya group were mostly concerned about the product evaluation (biscuit) than the experience of the exposure.

7.5 Future work on sorghum-soya biscuits

Currently the biscuit market is populated with biscuits made from wheat flour. The sorghum products that are available in the South African market include sorghum meal, instant breakfast porridge and fermented alcoholic or non-alcoholic beverages (Taylor et al., 2006). This shows that food product developers who are considering the manufacture of sorghum biscuits are faced with a huge challenge because most consumers are highly familiarised with wheat biscuits. Therefore, effective marketing techniques have to be implemented to ensure success of commercialisation of sorghum-soya biscuits. From the extensive research done on sorghum-soya biscuits focus should be on optimization of the biscuits. Figure 7.1 provides a summary of work that has been done in stages on sorghum-soya biscuits and the future work that can be taken after this research. The figure present a summary of work done thus far on sorghum-soya biscuits in this present study and by Serrem (2010).

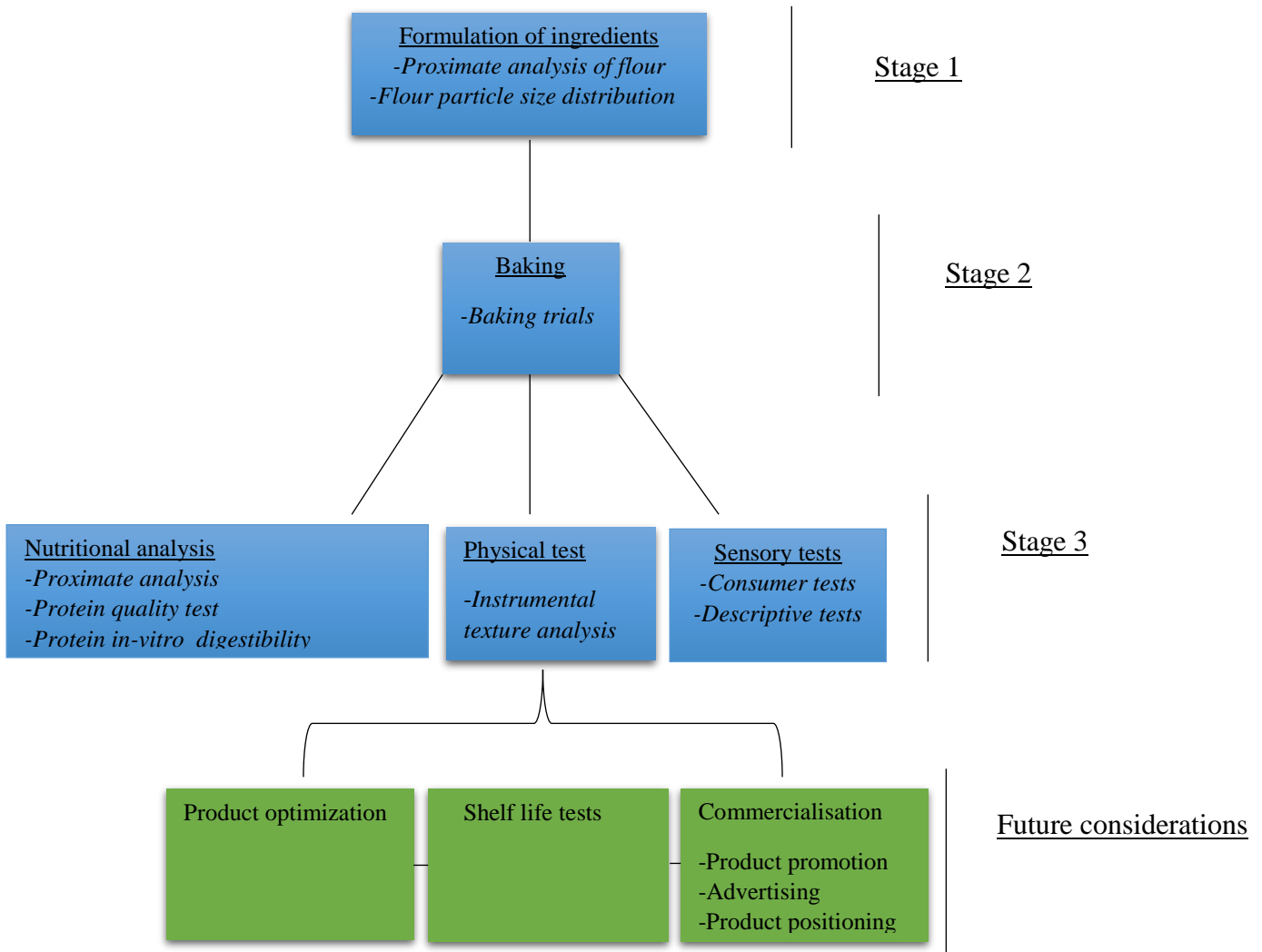


Figure 7.1: Brief details of the stages that have been done in the development of sorghum-soya biscuits as well as the future work. The summary of work done thus far on sorghum-soya biscuits as indicated above were done in this present study and by Serrem (2010)

7.5.1 Product optimization

The sorghum-soya biscuits were less acceptable compared to wheat biscuits during the pre, post and follow-up sessions. From the results mentioned above optimization of sorghum-soya biscuits are therefore vital. The optimization needs to be done so that the product meets the consumer expectations. Product optimization can include reformulation of the ingredients or changing the processing of the product (Earle and Earle, 1999). In this study, the product can be optimized by improving the sensory characteristics of sorghum soya biscuits. For example, empirical research done on sorghum biscuits has emphasised that the grittiness of the biscuits compromises their acceptance (Chiremba et al., 2009, Badi and Hoseney, 1976, Serrem et al., 2011). As such, there is need to improve the grittiness so that the biscuits become more desirable and acceptable. However, grittiness can be improved by fermenting sorghum flour before baking (Hugo, 2002).

7.5.2 Commercialisation

In the case of sorghum-soya biscuits, findings from this study suggest that repeated exposure to sorghum-soya biscuits can lead to an increase in liking to a niche consumer market. Therefore, before commercialisation the niche market has to be identified. For example, the target market can be health conscious consumers who are interested in traditional food products or gluten intolerant consumers. The price of the sorghum-soya biscuits can also appeal to many consumers because according to the estimation costs made by Serrem (2010) it was indicated that the manufacturing cost of 200g of sorghum-soya biscuits was R5.35 while the current online prices of gluten-free biscuits in the South African market range from R32.95 to R59.95 for a packet of 200g (*personal observation*).

Suzuki and Park (2018) suggested that positive product information can be used to effectively market unpleasant or commonly disliked food products. Due to the increase in chronic diseases such as diabetes, cardiovascular disease and cancer, some consumers have directed attention towards maintaining a healthy diet (Brown et al., 2011). Research has shown that the health benefits associated with the sorghum polyphenols include antioxidant, anti-inflammatory, cancer inhibitory, anti-arrhythmic activities and lowering of lower density lipoproteins (LDL) cholesterol (Taylor et al., 2006, Awika and Rooney, 2004, Dykes and Rooney, 2006). The above-mentioned health promoting properties of sorghum polyphenols can be used to effectively market sorghum-soya biscuits. A proposed product design specification of sorghum-soya biscuits is indicated in Table 7.3. This can be used to identify specific requirements that must be met before commercialising the biscuits.

Table 7.3: Product design specifications: Sorghum-soya biscuits

Product design specifications: sorghum-soya biscuits

1. Product Concept General Statement

Biscuits formulated from the underutilised African cereal grain (sorghum) and soya flour in order to address the protein and energy needs of modern health conscious African consumers. The biscuits are shelf stable and can be stored at ambient temperature. The biscuits are targeted at the gluten intolerant market segment as well as the health conscious consumers. Other extra ingredients include flavouring, vegetable oil and sugar.

2. Product qualities

Nutritional: High in protein (≈ 17 g/100 g) and energy (≈ 1943 kJ/100 g)

Sensory: Light brown in colour, good quality gluten free biscuits with a tender bite and vanilla flavoured

Physical: Circular shaped biscuit, light brown in colour ($L^*=47$ $a^*=9.1$ $b^*=14.7$ $c^*=0.7$)

Chemical: contains high protein and high energy content but contains an allergen “soya”

Microbiological: dry product and shelf stable (actual shelf life is yet to be determined)

Processing: process involves mixing of ingredients, sheeting, dough cutting, baking at 200 °C and cooling at ambient temperature.

Storage: shelf stable biscuits to be stored at ambient temperature

Packaging: not yet known

Price: will be determined after product optimisation

3. Target Consumer

The target consumer is the gluten intolerant segment, as well as the general health conscious consumers who are interested in traditional African food products. The product benefits to the consumer are that the biscuits are high in energy and protein an on-the-go snacks that can also be enjoyed by gluten intolerant consumers.

4. Proposed ingredients and functions

Ingredient	Function
Sorghum flour	Texture, nutritional and structure
Defatted soya flour	Texture, nutritional and structure
Flavours	Flavouring (vanilla)
Sugar	Flavouring and taste
Vegetable oil	Mouthfeel and texture
Water	Texture, mouthfeel and structure

5. Process

The production process has been designed (chapter 4) and tested as indicated in this study. A few adjustments can be made to the production process after the optimisation process

6. Formulation

The biscuit formulations will be standardised after the optimization process.

7. Packaging

The biscuits packaging is not yet known.

8. Government regulations

According to the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (ACT 54 OF 1972) the biscuits contain an allergen 'soya' hence it should be declared on the label of the packaging material that the allergen available is "soya".

9. Marketing and design specifications

Distribution: The biscuits will be distributed to retail supermarkets as well as health food stores

Price: Actual consumer price will be calculated after the product optimization process

Promotion: Product is meant for the consumers of health conscious and the gluten intolerant persons.

Product benefits to be promoted: gluten free, high protein, high energy,

Current competition: The current competition is the wheat biscuits available in the market.

The format of the product design specification template was accessed from Earle and Earle (1999). The Foodstuffs, Cosmetics and Disinfectants Act, 1972 (ACT 54 OF 1972) was accessed online from the website of National Department of Agriculture (2007). Source of the values of protein and energy content of the biscuits Serrem et al. (2011)

8 CONCLUSIONS AND RECOMMENDATIONS

The study showed that repeated exposure to sorghum-soya biscuits could lead to a positive development of liking. In addition, repeated exposure can be used as a strategy of increasing the liking of novel food products.

Other personal factors such as food neophobia propensity of consumers and familiarity with sorghum do not affect the liking of sorghum biscuits. Young consumers who are familiar with sorghum do not rate sorghum-soya biscuits any different from those who were not familiar with sorghum. The study revealed that the group of young consumers that participated in the study is more concerned with sensory attributes of food as opposed to familiarity.

The production and commercialization of a sorghum-soya biscuits will enable consumers to have access to such biscuits and the introduction of sorghum-soya biscuits into the commercial market might reduce the dependence on imported grains such as wheat. Sorghum-soya and sorghum biscuits can be marketed as healthy biscuits as they bring a healthy-feeling to consumers.

Optimization of the biscuits is highly necessary and this can be done through can be done through incorporating flavours such as ginger, chocolate, mint, cinnamon. The texture of the biscuits also needs improvement as recommended by consumers. Consumers recommended that the biscuits were not sweet enough so the sweetness of the biscuits also needs to be improved by adding more sugar.

Future research can be done to develop a standardized repeated exposure testing method. This can be done through conducting series of repeated exposure tests at different venues, with different age groups and on a variety of food products. The establishment of a standard repeated exposure test method might discourage food product developers to launch new products without conducting adequate research on the long-term acceptability of new food products.

Due to the various difficulties of conducting repeated exposure sensory evaluation, research should also be done on the long-term acceptance of sorghum-soya biscuits using a rapid exposure test such as the boredom test. Moreover, results from the boredom test might be compared with results from the repeated exposure test to determine the validity of each test in determining long-term acceptability of food products.

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10 APPENDICES

Appendix 1: Recruitment letter

Dear Sir/Madam

RE: CONSUMER EVALUATION OF NOVEL HIGH ENERGY, HIGH PROTEIN BISCUITS

The Department of Food Science, at University of Pretoria does research on the development of novel food products to help address the energy and protein needs of modern African consumers. As such, the products should be:

Safe, Ready for the Market, Affordable, Acceptable, African, Ready to eat as well as Trendy.

Consumers play a vital role in product development to obtain high market value products. For this research by Nomsa Chimuti, an MSc Food Science student we need a group of consumers who are willing to consume biscuits give us some feedback on the acceptability of the biscuits.

The biscuits were formulated using flour from an underutilised African cereal grain (sorghum) and soy flour to increase the protein content. These biscuits are intended to be an anytime snacks for those on the go, to give energy, protein and other health promoting properties. The biscuits may contain sorghum flour, wheat flour, soy flour, sugar, sunflower oil, vanilla essence and baking powder.

Participants will be asked to attend a 30-45 min biscuit tasting session on 14 February 2017 at a central location. During this session four biscuits will be evaluated. Thereafter participants will be given 4 biscuits asked to eat these four biscuit on 7 March 2017. On this day participants will be asked to give feedback via online survey. They will receive links to the survey via email. Following the home consumption session, participants will also be asked to participate in one more biscuit tasting session on 17 March 2017. The session on 7 March will be done at home while the session on 17 March will be done at a central location.

At the end of the study participants will receive a R100 gift voucher as well as a chance to win a lucky draw prize of a Menlyn gift voucher.

Yours truly,

Prof H.L de Kock (Study leader)

Nomsa Chimuti (MSc Student)

Appendix 2: Screening questionnaire

Good morning / afternoon / evening, my name is I am a field worker from the Department of Food Science, University of Pretoria. I am currently recruiting students who are willing to participate in a project to taste biscuits. As an incentive, each participant will receive a gift voucher worth R100. Each time you participate you stand a chance of winning a Menlyn gift voucher worth R1500, the final draw will be made at the end of the project.

Section 1: Participant screening

Would you be willing to consume biscuits as explained briefly in the letter?

Yes	<input checked="" type="radio"/>
No (terminate interview)	<input type="radio"/>

Do you have any food allergies?

Yes (If allergic to wheat, gluten or soy terminate the interview)	<input checked="" type="radio"/>
No	<input type="radio"/>

Do you have access to internet or Wi-Fi on a daily basis?

Yes	<input checked="" type="radio"/>
No (terminate interview)	<input type="radio"/>

In what year were you born?

1992	
1993	
1994	
1995	
1996	
1997	
1998	
1999	
If person doesn't fall within the age range stated above TERMINATE INTERVIEW	<input type="radio"/>
If person falls within the age range please continue with the interview	<input checked="" type="radio"/>

Availability:

Will you be able to consume biscuits on the day mentioned in the letter and give regular feedback via online survey?

Yes	<input checked="" type="radio"/>
No (terminate interview)	<input type="radio"/>

Will you be available to come for biscuit tasting sessions at a central location on these days?

	Yes	No
14 February 2017		
17 March 2017		
If yes	<input type="radio"/>	
(If No please terminate interview)		<input checked="" type="radio"/>

Are you still willing to participate in this research?

Yes (If yes please ask the participant to fill the information below.)	<input type="radio"/>
No (terminate interview)	<input checked="" type="radio"/>

Interviewer section: I
(Full name & surname) hereby declare that I have screened the respondent and that the above information is correct and valid.

Signature:

Date:

Appendix 3: Consent form

Consumer Perception of Foods: Cereal-legume composited biscuits

Research student Ms Nomsa Chimuti Department of Food Science, University of Pretoria Private Bag X20, Hatfield, 0028 South Africa Tel: 0623532364 nomsastix@gmail.com	Principal Investigator: Prof H L de Kock Department of Food Science, University of Pretoria Private Bag X20, Hatfield, 0028 South Africa Tel: 012-420 3238 riette.dekock@up.ac.za
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PURPOSE: The purpose of this MSc Food Science project is to determine the acceptability of high energy, protein-rich biscuits.

PROCEDURES:

1. Session 1

Activity: Taste four biscuits and complete an online survey on a computer or tablet. Collect 24 biscuits to consume at home.

Venue: West City, TUT residence, Pretoria West

Date : Monday 13 February 2017

Time: The activity will take approximately 30 min

2. Consumption at home phase

Activity: Consume one biscuit every day, for **20** days (**including weekends**) and complete a short online survey that will be sent to you via email. **YOU WILL NEED INTERNET ACCESS TO COMPLETE THE SURVEY.**

3. Session 2

Activity: Taste four biscuits and complete an online survey on a computer or tablet.

Venue: West City, TUT residence, Pretoria West

Date : Thursday 16 March 2017

Time: The activity will take approximately 30 min

RISKS:

The risk involved in eating the biscuits is no greater than that of eating biscuits purchased in a retail market. The biscuits that you will be asked to consume contain the following ingredients: soy flour, wheat flour, sorghum flour, sugar, sunflower oil, vanilla essence and baking powder. Any person who is allergic to soy or wheat should not participate.

BENEFITS:

In participating, you will contribute towards the better understanding of consumer acceptance of cereal-soy biscuits and the market potential of the products.

REMUNERATION OR GRATIFICATION:

Each participant will receive R100 as well as a chance in a lucky draw of a gift voucher.

CONFIDENTIALITY: The information collected during this project will be kept strictly confidential. ‘Confidential’ means that your name and the information collected about you will be linked by a code number, and the code number will be used to identify your data. Your name will therefore not be linked directly to any of your data. All data will be kept in a locked filing cabinet or on a password protected computer in the Principal Investigator’s laboratory. Only research staff involved in the study or the Ethics committee (a committee that reviews research studies in order to protect research participants) at the University of Pretoria will be authorized to see the data, except as may be required by the law. If a report of this study is published, or the results are presented at a professional conference, only group results will be stated. You will not be personally identified in any report or presentation of this research. If you decide at any stage not to participate, you can let us know and we will delete your information.

YOUR RIGHT AS A RESEARCH PARTICIPANT:

Your participation in this project is completely voluntary and you have the right to withdraw at any time without explanation or penalty.

DISCLAIMER:

The University of Pretoria, nor any of its representatives, can be held responsible in the unlikely event of any injury or illness as a direct or indirect result of your participation in this project.

CONTACT INFORMATION:

You can contact the Principal Investigator at the number listed above if you have any questions about this study. If you have any questions about your rights as a research subject, you may contact the Faculty of Natural and Agricultural Sciences Ethics Review committee.

Adri.Oneill@up.ac.za

Name of the participant (print) _____
Date

Signature of participant _____
Signature of investigator

Please confirm that you received a copy of this statement for you record _____ (Your Initials)
This informed consent form was approved by the University of Pretoria Faculty of Natural and Agricultural Sciences Ethics Review committee (Ethics reference number _____).

Date: _____

Appendix 4: Questions regarding biscuits asked on pre-exposure, post-exposure and follow-up

Please rate how much you like or dislike the **smell** of biscuit [3-digit code]

Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike very much	Dislike extremely

Please rate how much you like or dislike the **appearance** of biscuit [3-digit code]

Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike very much	Dislike extremely

Please rate how much you like or dislike the **taste** of biscuit [3-digit code]

Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike very much	Dislike extremely

Overall, how much you like or dislike biscuit [3-digit code]

Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike very much	Dislike extremely

Appendix 5: Food neophobia scale

Please indicate how much you agree or disagree with the 10 statements

Disagree strongly	Disagree moderately	Disagree slightly	Neither agree or disagree	Agree slightly	Agree moderately	Agree strongly
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FOOD NEOPHOBIA SCALE (FNS)

1. I am constantly sampling new and different foods.
 2. I don't trust new foods.
 3. If I don't know what is in a food, I won't try it.
 4. I like foods from different countries.
 5. Ethnic food looks too weird to eat.
 6. At dinner parties, I will try a new food.
 7. I am afraid to eat things I have never had before.
 8. I am very particular about the foods I will eat.
 9. I will eat almost anything.
 10. I like to try new ethnic restaurants.
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Appendix 6: Food choice questionnaire

It is important that the food I eat on a typical day

	Not at all important Little important Moderately important Very important			
	1	2	3	4
1. Contains a lot of vitamins and minerals				
2. Keeps me healthy				
3. Is nutritious				
4. Is high in protein				
5. Is good for my skin/teeth/hair/nails etc.				
6. Is high in fibre and roughage				
7. Helps me cope with stress				
8. Helps me to cope with life				
9. Helps me relax				
10. Keeps me awake/alert				
11. Cheers me up				
12. Makes me feel good				
13. Is easy to prepare				
14. Can be cooked very simply				
15. Takes no time to prepare				
16. Can be bought in shops close to where I live or work				
17. Is easily available in shops and supermarkets				
18. Smells nice				
19. Looks nice				
20. Has a pleasant texture				
21. Tastes good				
22. Contains no additives				
23. Contains natural ingredients				
24. Contains no artificial ingredients				
25. Is not expensive				
26. Is cheap				
27. Is good value for money				
28. Is low in calories				
29. Helps me control my weight				
30. Is low in fat				
31. Is what I usually eat				
32. Is familiar				
33. Is like the food I ate when I was a child				
34. Comes from countries I approve of politically				
35. Has the country of origin clearly marked				
36. Is packaged in an environmentally friendly way				

Appendix 7: Purchase intent questionnaire

How likely are you to buy this biscuit if it were available in the stores where you normally shop?

Definitely would buy	Probably would buy	Might or might not buy	Probably would not buy	Definitely would not buy

Appendix 8: Enjoyment/Boredom scales

How did you find the experience of tasting biscuits for 20 days? Please rate using the scale below.

Not boring at all	Very boring	Moderately boring	Slightly boring	Extremely boring

Extremely fun	Very fun	Moderately fun	Slightly fun	Not at all fun

Appendix 9



Figure 10.1: Consumers comments on 100 % wheat biscuits during the repeated exposure phase

Appendix 11



Figure 10.3: Consumers comments on wheat-soya biscuits during the repeated exposure phase



Figure 10.5: Consumers comments on the exposure experience