CONSUMER PROFILING AND QUALITY CHARACTERISTICS OF COMMERCIALLY TRADED ORANGE- FLESHED SWEETPOTATO PUREE BREAD IN KENYA

BY

WANJUU CECILIA WAMBUI

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(BSc. FOOD SCIENCE AND TECHNOLOGY, UNIVERSITY OF NAIROBI)

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Department of Food Science, Nutrition and Technology

UNIVERSITY OF NAIROBI

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This dissertation has been submitted with our approval as Supervisors:

Dr. George O. Abong'

Department of Food Science, Nutrition and Technology.

University of Nairobi

Signature………………………………. Date…………………………….

Dr. Tawanda Muzhingi

International Potato Centre

Signature………………………………. Date…………………………….

DEDICATION

I dedicate this work to my parents, Peter Wanjuu Mbugua and Lucy Muthoni Wanjuu for the great solid foundation they have given me, the support, prayers and invaluable encouragement all through the years.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BSE	- Bovine Spongiform Encephalopathy
CIP	-International Potato Centre
GAP	- Good Agricultural Practices
GMO	- Genetically Modified Organisms
GMP	- Good Manufacturing Practice
OFSP	- Orange Fleshed Sweetpotato
PCA	- Plate Count Agar
PDA	-Potato Dextrose Agar
TVC	-Total Viable Count
VAD	- Vitamin A Deficiency
WHO	- World Health Organization

Abstract

Orange fleshed sweetpotato (OFSP) is a biofortified crop rich in provitamin A carotenoid. OFSP puree has been used as a major ingredient in processing of baked products. However, partial replacement or substitution of wheat during baking of bread and product handling affects the quality of the final product and therefore the need for the current study to determine the quality and shelf-life of OFSP puree-wheat flour composite bread contingent to consumer handling practices. The current study involved a cross-sectional survey to profile consumers of OFSP puree-wheat flour composite bread in selected Tuskys stores in five counties; Nairobi, Kiambu, Kajiado, Kakamega and Kisumu and laboratory analysis to determine the quality and shelf-life of OFSP puree-wheat flour composite bread compared to the white bread as per information obtained from the survey. The shelf-life was determined by analyzing bread physiochemical properties for seven days after storage at 7^{o}C, 20^{o}C, 25^{o}C and 30^{o}C.

One thousand and twenty-four (1024) consumers participated in the survey. OFSP puree-wheat flour composite bread is purchased mostly by female respondents (60%), who have completed their university education (79.3%), formally employed (93.1%), therefore, middle to high income earners. Consumers from Western and Nyanza regions of Kenya were better informed about the OFSP root. After purchase, 42% of the consumers stored their bread in the open, 38% store in the refrigerator and the rest in cupboards. Consumers agree that OFSP bread could be a source of energy, vitamins, especially Vitamin A (93.8%), and minerals. The acceptance ratings for OFSP bread ranged from 7.4 to 7.7 on a 9-score hedonic scale, therefore “liked moderately”. There was a significant value ($p< 0.01$) relationship between consumer demographics, knowledge about the bread and root and acceptance of OFSP puree-wheat flour composite bread as indicated by the positive correlation coefficient value. Consumers were willing to pay more for the orange flesh sweetpotato puree-wheat flour composite bread considering the potential nutritional benefits derived from the bread.

A significant ($p<0.05$) decrease in moisture content was exhibited in bread stored at 7^{o}C. Refrigeration preserved both OFSP and white bread hence no microbial growth, while increase in water activity and storage temperature led to fast spoilage, especially the white bread. The initial β-carotene levels of OFSP puree-wheat flour composite bread ranged between 0.0498-0.0532 mg/100g. These significantly ($p<0.05$) decreased after storage, ranging between 0.0263-0.0277 mg/100g due to thermal degradation. β-carotene was non-detectable in white bread. The color of the crumb and crust significantly ($p<0.05$) decreased with increase in storage temperature. Refrigeration temperatures increased ($p< 0.05$) hardness, firmness, cohesiveness and chewiness of the bread, whereas increase in incubation time decreased ($p<0.05$) resilience.

Public awareness, knowledge and attitude and socioeconomic factors influence consumer practices and acceptance of orange fleshed sweetpotato puree-wheat flour composite bread and should be considered during product marketing. OFSP puree-wheat flour composite bread had a longer shelf-life than white bread. It is recommended to store bread at refrigeration temperature as it preserved the quality of the bread even though the staling process is accelerated at these temperatures. This can be reverted by reheating the bread before consumption.

Keywords: shelf-life, Orange fleshed sweetpotato, puree bread, Vitamin A, preferences,

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND INFORMATION

The orange-fleshed sweetpotato (OFSP) has the potential to decrease Vitamin A Deficiency (VAD) in Africa especially in the Sub-Saharan (Kapinga et al., 2005) as compared to the white-fleshed which is high in dry matter content but has minimal amounts of the vitamin. Consumption of Vitamin A-rich food has significantly increased in Kenya especially in the Western region, Busia and Bungoma Counties. Through Sweetpotato Action for Security and Health in Africa (SASHA) initiative, a project under the International Potato Center (CIP), pregnant women and or women with children below 5 years accessing antenatal care services at local dispensaries are targeted. The women access both nutritional information and OFSP vines for subsistence or commercial cultivation. This ascertains availability of Vitamin A in the diet especially for the children (Ouedraogo, 2011).

OFSP has proven to be important for food security in this region and is consumed regularly in young families. The use of OFSP has scaled up in Kenya, Uganda, Mozambique, Rwanda with commercialization of the sweetpotato where processed products contain OFSP as a major ingredient (Low and Jaarsveld, 2008). OFSP is significantly contributing to livelihoods in the urban and rural areas in both the aspects of food quality and nutrition as a source of $\beta-$Carotene , vitamins, dietary fiber and minerals (Mills et al., 2009). The tuber is both drought resistant and easily cultivated and hence available through-out the year (Stathers et al., 2013).

Production-focused interventions through supplementation, dietary diversification and fortification have led to increase in vitamin A intake in the Sub-Saharan Africa (SSA) (Jenkins et al., 2015). β−carotene serves as an important nutritional component in foods, as a precursor of vitamin A, and provides pleasant yellow-orange color to foods as in the OFSP (Kapinga et al., 2005) . The roots are usually boiled or stewed for consumption at household level. (Vimala et al., 2011). OFSP has recently proven to be an important ingredient in the processing of baked products such as bread, biscuits, cookies and cakes (Mazuze, 2004).

Consumers demand food products of high-quality, which are safe, natural with colors and flavor, easy to use as well as with an extended shelf life (Kourkoutas et al., 2016). Their knowledge about the health benefits from a specific or various functional ingredients is linked to their acceptance of a product containing these ingredients. Such ingredients include vitamins, fiber, minerals such as iron and calcium all of which achieve substantially high rates of customer acceptance (Mills et al., 2009). Benefits from the consumption of functional foods are associated with different advantages to human health and quality of life (De Moura et al., 2015). A product may not be accepted by consumers even if it has been proven to have health benefits and is not attractive to consumers or it's sensory properties do not meet consumer expectations (Menrad, 2003).

The quality of bread is defined by its characteristics that range from nutritional aspects, functional properties, sensory properties (appearance, texture, taste and aroma) and physiochemical constituents. Various parameters can be used to determine the quality of fresh commodities (Popper et al., 2004). The level of consumer acceptability is then assessed by asking consumers to rate how much they like a product (Menon et al., 2015). This further leads to defining consumer satisfaction and contentment about the specific product. The aim of the current study was to determine consumer acceptance, willingness to pay, knowledge and handling practices and hence the quality and shelf-life of OFSP puree-wheat flour composite bread.

1.2 Problem Statement

The production of orange fleshed sweetpotato baked products has increased in Kenya and in the Sub-Saharan Africa purposively to enhance the role of the crop in ensuring food security, nutrition and income generation to small-scale farmers in the region (Kapinga et al., 2005). In Kenya, OFSP puree has proven to be economically feasible in baking of bread, buns and scones which can contribute substantially to increased and diversified sources of vitamin A. Wheat substitution during bread baking alters the nutritional, organoleptic and keeping quality of the final product (Onyango et al., 2010). These aspects are also dependent on consumer behavior and how they handle the product before consumption. The keeping quality and microbial stability of OFSP puree-wheat flour composite -wheat composite bread contingent to consumer handling practices are yet to be established, even though the bread is currently commercially available.

1.3 Justification

Food safety, quality and nutritional issues are being addressed worldwide with an effort to achieve food security and efficient utilization of nutrients (Gomes et al., 2013). Food, during processing and marketing undergoes several stages and many food handlers throughout the food chain. In developing countries, up-to-date technologies which should be efficient and safe for processing and storage of processed foods are lacking and so is the knowledge of food safety along the food chain and among the stakeholders (Byrd-Bredbenner et al., 2015). Failure to adhere to good manufacturing practices (GMP), good agricultural practices (GAP), and food safety management systems has been known to be the cause of increase in foodborne illness especially in small scale production (Kussaga et al., 2014) . Establishing microbial quality of current OFSP baked products in Kenyan markets will provide information needed to make informed choices on the safety and quality OFSP bread leading to an increase in production capacity and consequently increased primary production at the farm level in Africa. This will establish a variety of demographic and psychographic characteristics that determine consumers' buying behaviors, risk patterns, and levels of profitability.

1.4 Objectives

1.4.1 Overall Objective

To determine consumer knowledge, practices and the quality and shelf-stability of OFSP puree-wheat flour composite -wheat composite bread in Kenya.

1.4.2 Specific Objectives

1. To determine current consumer demographic, knowledge, handling practices, sensory acceptance and willingness to pay for the OFSP puree-wheat flour composite bread in Kenya
2. To determine the physiochemical properties and shelf-life of OFSP puree-wheat flour composite bread under different temperature of storage

1.5 Hypotheses

1. Use of OFSP puree-wheat flour composite bread in bread baking does not affect consumer demographics, knowledge, handling practices, sensory acceptance and willingness to pay for the OFSP puree-wheat flour composite bread

2. Substitution of wheat flour with OFSP puree does not affect the quality and shelf-stability of bread

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin of sweetpotato

Sweetpotato (*Ipomoea batata*) was first cultivated at least 5,000 years ago, in the tropics of Central America. It is believed that the Portuguese traders introduced the root to Africa in the 16th century possibly through the east and west coasts before it spread inland. The Indians and British colonials could have also introduced the sweetpotato to East Africa (Stathers et al., 2013). Sweetpotato can be vegetatively propagated, or multiplied through the cuts or replanting of vine segments. It is a hardy crop that often succeeds when other crops succumb to stress such as drought and is not as labor and cost intensive as many other staple crops (Jenkins et al., 2015; Stathers et al., 2013). Sweetpotato roots provide all essential vitamins including several B vitamins, Vitamin C and E and minerals such as potassium, iron and zinc (Stathers et al., 2013) . There are several varieties of OFSP that are very rich in pro-vitamin A or beta-carotene. Vita and Kabonde varieties are popularly grown in Kenya (Low and Jaarsveld, 2008).

2.2 The Orange Fleshed Sweetpotato and Nutrition

OFSP is one food-based approach that has great prospect of reducing cases of Vitamin A Deficiency (VAD) in Sub-Saharan Africa (Kapinga et al., 2005) and it has been an important food security crop, classified as an energy-dense food (Jenkins et al., 2015). Vitamin A (retinol) is an essential micronutrient; meaning it should always be available in the diet as it is not synthesized by the body (De Moura et al., 2015). Beta-carotene is converted into vitamin A (retinol) in the intestines and liver upon consumption. Vitamin A is responsible for growth and development, visual adaptation to darkness hence improved eye sight, gene expression and improvement and development of the immune system (De Moura et al., 2015) . Earlier on, the white-fleshed sweetpotato was highly preferred because of its high dry matter content and hence satiety despite its low carotenoid level (Jenkins et al., 2015). Supporting data confirms that OFSP is a highly affordable source of vitamin A (Hotz et al., 2012; Islam et al., 2016; Jamil et al., 2012).

β-carotene, a pro vitamin of Vitamin A is found in high amounts in OFSP (Low et al., 2007). In addition, the OFSP has substantial amounts of carbohydrates, fats, protein, dietary fiber, micronutrients such as sodium and calcium, potassium, iron, zinc, thiamine, niacin, riboflavin and ascorbic acid (Mills et al., 2009). Sweetpotatoes also contain some phytonutrients like anthocyanins, carotenoids, flavonoids, folates and phenolic compounds (Oke and Workneh, 2013). Therefore, OFSP is a staple food that can provide energy as well as nutrients especially vitamin A to people in developing countries (Mitra, 2012). Further, OFSP has gained popularity as a source of anti-oxidant with beneficial physiological attributes such as anti-cancer, anti-oxidation and cardiovascular disease prevention. The crop is therefore best suited to combat malnutrition in the marginalized communities (Stathers et al., 2013).

Bio accessibility of β-carotene depends on various factors such as dietary fat which is mostly necessary for absorption of β-carotene and its conversion to retinol. It has been reported that heat processing and maceration improves β-carotene bio availability from OFSP (Islam et al., 2016; Tumuhimbise et al., 2009). Heat raptures the microstructure of plant tissue and subsequently releases nutrients from the complex matrix of the food (Tumuhimbise et al., 2009). The retention and bio accessibility of β-Carotene after processing and storage of the OFSP determine its bioavailability (De Moura et al., 2015). However, further reports indicate that carotenoids are significantly reduced when exposed to heat and stored for an extensive period (Tumuhimbise et al., 2009; Vimala et al., 2011). Carotenoids have a highly unsaturated structure which makes them susceptible to environmental conditions post-harvest such as heat during cooking and processing, high oxygen levels and light (Guiamba et al., 2015; Tumuhimbise et al., 2009). β-Carotene content vary considerably depending on the cooking methods, post-harvest processing, environmental conditions and duration of storage (De Moura et al., 2015).

2.3 Diversification in OFSP Utilization

Extensive and innovative works are being carried out by International Potato Centre (CIP) in the Sub-Saharan Africa in countries such as Ghana, Angola, Zambia, Malawi, Kenya, Mozambique and Tanzania (Stathers et al., 2013). SUSTAIN (Scaling Up Sweetpotato Through Agriculture and Nutrition) program in Kenya is currently working in five counties in Nyanza region and Busia County in the Western region of Kenya reaching households with children aged 5 years and below and or pregnant women. The purpose of this program is to provide those who have subscribed with OFSP vines and nutrition education with the expected outcome of increase in frequency of OFSP cultivation and consumption (Muoki and Agili, 2015). There has been significant increase in cultivation leading to commercialization of the OFSP where the sweetpotato is used as a major ingredient in the processing of bread, biscuits, cookies and juices (Stathers et al., 2013).

At household level in the marginalized areas, OFSP is processed into shelf-stable intermediate products such as grits and flour which are then made to various value-added products for consumption including chapatti, mandazi, doughnuts, juice, salad and vegetable relish (Kuloba, 2013; Stathers et al., 2013). The acceptance of the OFSP has led to increase in the utilization of the root at industrial level in the processing of baked products such as bread, cakes and biscuits (Muoki and Agili, 2015; Stathers et al., 2013). Diversification and modification in the utilization of OFSP results to increased consumption of vitamin A from the resultant variety of products provided the product does not undergo significant losses of β-carotene during processing due to heat exposure and storage conditions (Vimala et al., 2011; Bechoff et al., 2011).

2.3 The process of bread baking

The process of bread baking is complex involving numerous physiochemical and biological reactions such as absorption and evaporation of water, volume expansion, gelatinization of starch, protein denaturation and maillard reactions for crust formation (Anishaparvin et al., 2010). Bread baking involves four key ingredients: water, wheat flour, yeast and salt while other additives include shortening and sugar (Onyango, 2016). The process of bread baking in Tuskys bakery is as shown in Figure 1. The ingredients including OFSP puree are weighed and mixed for 5 minutes in a Tombak bakery and confectionary F2 mixer. The dough is then cut and weighed in to 400g and then molded into rolls which are then placed in bread pans. The dough is allowed to proof for 45 minutes in a proofing cabinet. This allows for the dough to relax and yeast to produce carbon IV oxide allowing the dough to rise to a desirable loaf volume (Onyango, 2016). The dough is then baked in a FİMAK Rotary Oven at 210°C for 30 minutes. During baking, heat transfer occurs by conduction, radiation, and convection (Anishaparvin et al., 2010). The loaves of bread are de-panned and allowed to cool to room temperature. The loaves are then sliced and packaged for distribution.

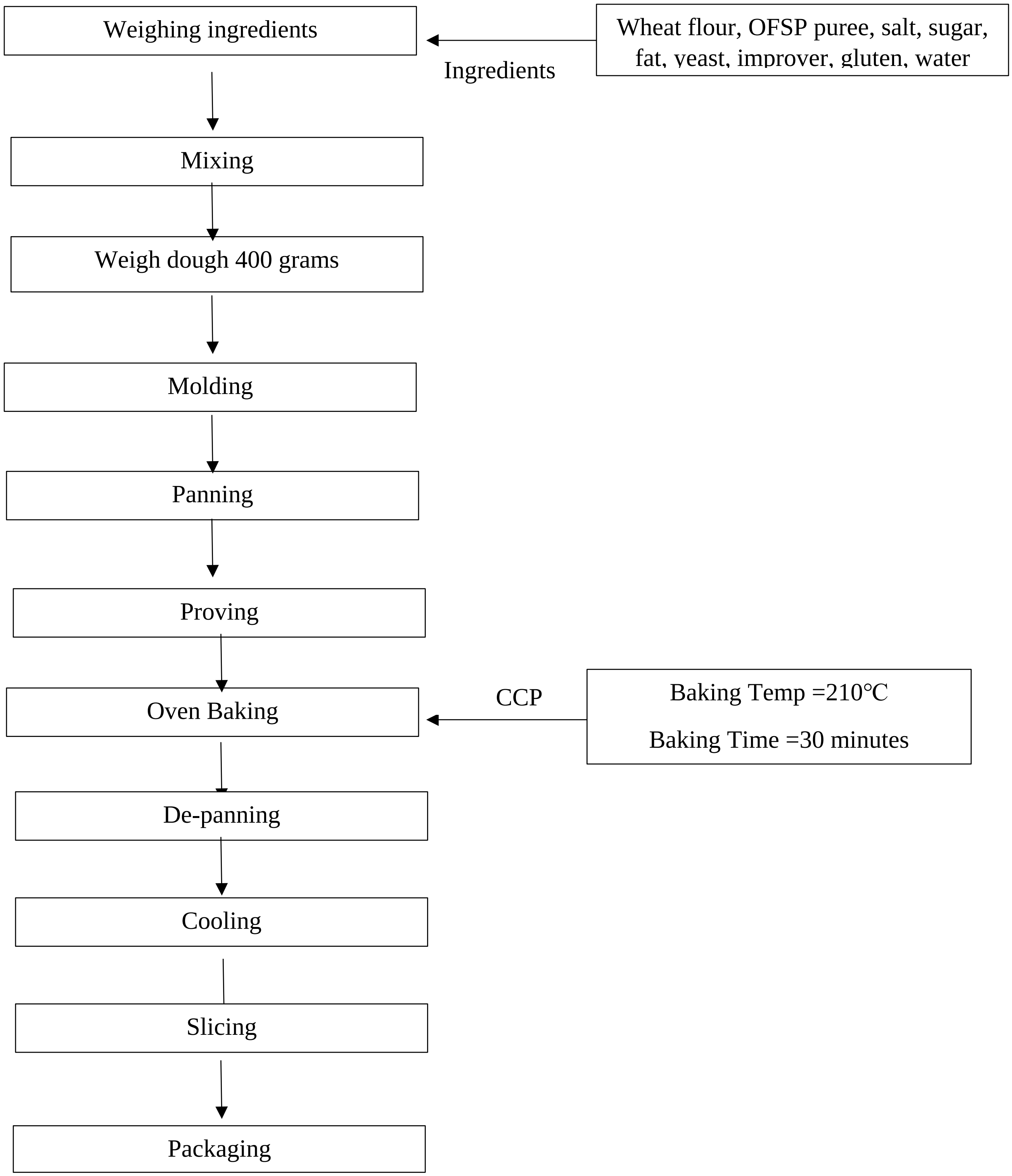

Figure 2.1 OFSP puree-wheat flour composite -wheat bread composite baking process

2.4 The chemistry of bread making

Bread is a common staple food consumed in the world. It is traditionally made from flour derived from the cereal, wheat and a variety of ingredients such salt, water, sugar, yeast and fat (Ngemakwe et al., 2015).

Wheat flour is the major ingredient used in baking of bread and other baked products. Wheat flour is a source of energy due to its high starch content, dietary fiber, protein (glutamine and proline, but low in lysine) and essential fatty acids (OECD, 2003). In addition, wheat flour provides important micronutrients such as minerals, B vitamins, phytochemicals and antioxidants (Gellynck et al., 2008). The functional components of wheat flour are the polymeric glutenin and gluten-forming monomeric gliadins which are about 80% - 90% of the total proteins, the rest being globulins and albumins (Sivam et al., 2011). The strength and elasticity of the dough depends on glutenin while gliadins impact on viscosity during dough development. There is need for mixing and kneading the dough to assist the proteins uncoil making their interaction easy for the formation of a strong network (Kouassi-Koffi et al., 2014). The proteins when hydrated, interact forming disulfide cross-linkages and hydrogen bonds subsequently forming a massive gluten network in the dough. Glutenin and gliadins wheat proteins are also involved in gelatinization, caramelization and maillard reactions during dough development and baking which are important in flavor and texture formation (Ngemakwe et al., 2015; Kouassi-Koffi et al., 2014).

Water plays a major role in the shelf-life as well as the textural properties of bread such as firmness of the crumb and crispness of the crust. Water is the dispersing agent during bread mixing process, its major role being to ensure dough rheology.(Arendt et al., 2007; Ngemakwe et al., 2015). Water hydrates the ingredients, dissolves the soluble ingredients and hence the interaction for proteins, carbohydrates and fat for the development of dough (Rinaldi et al., 2015). Starch degradation occurs due to activation of amylases during mixing with water. The protein fractions from wheat require to be hydrated for development of dough viscoelasticity and starch gelatinization during baking (Gallagher, 2009; Ngemakwe et al., 2015). Increase in protein content and flour extraction increases water absorption and hence, the amount of water to be added. Addition of water increases the extensibility of the dough and decreases the viscosity (Sivam et al., 2011). Inadequate water addition results to rapid hydration so that the dough formed is brittle, inconsistent and hence a marked 'crust' effect which affects the textural properties of the bread (Abu-Ghoush et al., 2007; Ngemakwe et al., 2015).

Salt improves the gluten network as well as adds flavor and preserves the bread (Jideani and Vogt, 2015; Rinaldi et al., 2015). Salt controls water imbibition and swelling of wheat flour proteins which consequently decreases dough extensibility and improves gas retention (Arendt et al., 2007). This will affect the texture and slicing properties of the bread crumb (Arendt et al., 2007; Ngemakwe et al., 2015).

Yeast *(Saccharomyces cerevisiae)* is used in the baking industry due to its ability to produce gas through the glucose fermentation and also improve on rheological properties of the dough (Gray and Bemiller, 2003). Starch and sugars in the dough are first broken down by amylase enzyme to maltose and then into glucose. Under anaerobic conditions, yeast ferments glucose, producing carbon iv oxide and ethanol. The carbon iv oxide formed goes into the dough matrix and when it's saturated, it is released into a gas cell that is formed during dough mixing. The by-products of glucose fermentation also contribute to the flavor of baked products (Ngemakwe et al., 2015).

Sugar is not only involved in sweetening the bread, but also in fermentation and caramelization hence the browning of the crust. The elasticity and stability of the dough depends on the amount of sugar added (Ngemakwe et al., 2015). Maillard reaction are due to a series of reactions between amino acids and sugars that occur during baking temperatures. The products from these reactions contribute to the flavor of the bread and the formation of the brown crust (Gellynck et al., 2008; Shimamura and Uke, 2012). Fat contributes to the shortening of the dough and hence affects the volume of the loaf. The crumb firmness and crust silkiness depend on amounts of fat added (Ngemakwe et al., 2015).

2.4.1 Bread Quality Aspects

The texture of bread and other baked products is a characteristic of starch, a major component of wheat (*Triticum aestivum L.)* endosperm (Yi et al., 2009). Gelatinization of starch during dough development determines the texture of bread and hence the bread quality specifically, the ability to retard staling. In early stages of baking, gelatinized starch granules sustains carbon iv oxide gas pressure which results into uniform gas cells, consequently, bread with a desirable texture and expansion characteristics (Tsai et al., 2012; Yi et al., 2009).

Specific volume (cm^3/g) of bread is characterized by factors such as composition of the dough , dough rheology and the processing conditions which also impacts on the gas retention capabilities, and consequently texture (Trappey et al., 2015).

A loaf of bread starts to deteriorate when it is removed from the oven due to a series of chemical reactions and the storage environment. The process of staling causes change in the taste and texture of the bread (Gallagher, 2009; Gellynck et al., 2008). The crumb of the bread becomes hard and dry while the crust becomes leathery and soft (Gellynck et al., 2008).

2.5 Food Safety

The need for food safety awareness has spurred in the both the public and the government due to the realization that food safety is a major indicator of growth of the economy more so in the developing countries and contributory to food security (Akhtar et al., 2014). Food safety has become an emerging issue of paramount importance with concerns raised including biotechnology, pesticides residue levels, food additives and microbes and pathogens, all of which have been identified as determinants of disease burden in Sub-Saharan Africa (Borchers et al., 2010; Hartung and Koeter, 2008). According to Dworkin et al., (2013), the emergence of food safety has been attributed to increased literacy in the society, increased demand for basic life necessities and hence the need for food security for improved life standards as mandated by regulators based on food policies and legislation. The weaknesses in the food supply chain characterized by unsatisfactory conditions of hygiene and sanitation due to lack of or misuse of resources are a possible cause for foodborne diseases (Grace, 2015). In some cases, it is unfortunate that microbes can survive many food production and processing operations therefore posing threat to human health due to foodborne illness (Akhtar et al., 2014) .

2.6 Methodology review

The measurement of color has gained much attention from food industries and food scientists. This is because color is a critical quality parameter influencing consumer acceptance (Gacheru, 2015). Spectrophotometers have long been used to determine color by principle of reflected or transmitted light at points on the visual spectrum, which results in a unique curve that can be used to specify and identify a matching color. Recently, handheld spectrocolorimeter are being used as alternatives. A color meter emulates how the human eye responds to light and color, usually as a three-filtered (tri-stimulus) for the colors red, green, and blue. A digital camera or a smartphone, reads out the color information and allows for quantitative analysis by reading out the color information (Martinez et al., 2007). The information is obtained as a grayscale or RGB channel values based on the relationship between analytic concentration and color information. Since the grayscale cannot follow multiple changes in color, it requires one to set a standard for each color analysis. Reporting is based on the CIE L*a*b* color system that has three coordinates L*, a*, and b* (Komatsu et al., 2016).

The moisture content of food products has been previously analyzed using the hot air oven method which was cumbersome and time consuming requiring overnight drying. (Ahmed et al., 2010; Ayub et al., 2003; Ahmad et al., 2014). Recent technological advancement have resulted to the halogen evaporator that rapidly analyzes the moisture content and gives prompt results (Nielsen, 2010).

2.7 Consumer profiling

Consumer acceptability of a new product is a critical factor for purposes of its marketability. Product development should be approached from the consumers' tastes and preferences. Consumers' perception is influenced by the color, texture, flavor, freshness and nutritional significance of the product (Gellynck et al., 2008; Rocha-Guzman et al., 2012). Consumer product acceptance influences the extent to which they are willing to change their behavior. Insufficient or low acceptance of interventions interprets to the consumer disliking the product, consequently not purchase it or perform the desired behavior. Sufficient acceptance on the other hand elicits product validation, so that consumers are more likely to approve the intended behavior (Gellynck et al., 2008).

Product acceptance is also crucial even on stakeholders part to allow for novel product implementation (Borchers et al., 2010). Bos et al., (2015) reports that despite the importance of the process of product acceptance, extensive knowledge on this processes and intervention strategies for food choices is lacking. Food scientist rely on consumer's beliefs and attitudes when it comes to food choices (Oriana et al., 2016). Beliefs are the cognitive knowledge, while attitudes are the affective response or feelings of the consumers with regard to a product and its benefit (Gellynck et al., 2008). Consumers criteria for evaluating a food product is complex as it involves ones individuality and multiple product characteristics which should satisfy a consumers' expectations and requirements (Jacoby et al., 1998). Internal (subjective) and external (objective) factors contribute to consumer perception. Consumer goals and motives also affect subjectivity or perception in determining their attitude, preference and choices (Gellynck et al., 2008).

The process of product acceptability starts with the collecting and categorizing intrinsic and extrinsic features of a product (Gellynck et al., 2008; Troy and Kerry, 2010). Intrinsic features are the characteristics of the product for instance, color, appearance, size and shape while extrinsic features are related to its price, quality and brand name (Beriain et al., 2009). These features form the perception about the quality attributes of the product so that a distinction is made about experience and credence attributes (Beriain et al., 2009; Gellynck et al., 2008). Experience directly affects consumers at the time of consumption and could include attributes such as freshness and food sensory characteristics. Credence quality attributes such as naturalness and healthiness are perceived indirectly. Credence attribute will require high level of elucidation for clarification purposes. The properties of food (safety, sensory and health attribute), socio-demographic (gender, age, family status and size) and marketing factors are determinants of perceived quality (Gellynck et al., 2008; Giles et al., 2015; Langiano et al., 2012; Zhang et al., 2015). Economic and marketing variables such as price, quality, nutrition labelling and traceability are some of the environmental factors influencing consumer perceptions and acceptance (Gellynck et al., 2008).

Food safety concerns to consider during introduction of novel products may include life-threatening health risks, such as weight gain and food allergies and hence the need for labelling (Hathwar et al., 2012). At processing level, microbiological risks from poor hygiene are much more serious due to health and cost implications than those related to food contamination early in the food production chain (Knowles et al., 2007). According to Banati (2008), consumers' concern about safety of food has been fueled by ever-emerging risks such as food poisoning and the use of new techniques and technologies such as social media which has been key to creating awareness.

Despite the significant developments in food science and technology and increase in consumer awareness about preparation and consumption of safe food, foodborne illnesses are still a health threat and an economic concern in both developing and developed countries (Byrd-Bredbenner et al., 2015). Just a few of food-borne outbreaks and illness caused by pathogens have attracted the attention of the policy makers, food scientists and media. Written and broadcast media influence consumers' preference and hence their purchase choice. Risk perceptions with regard to food safety issues differ between individuals and are influenced by individual preferences (Dong and Li, 2016). For instance, awareness instills fear to consumers so that they refrain from purchasing and hence consumption of such products as was the situation with BSE in Europe (Jansen et al., 2016).

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CHAPTER THREE

3.0 Handling Practices of Orange-Fleshed Sweetpotato (OFSP) Puree-wheat flour composite -Wheat Composite Bread Consumers in Kenya

Abstract

OFSP value addition involves increased diversity in its utilization to create market opportunities for the crop which is rich in pro-vitamin A. OFSP puree is currently used as a major ingredient in the processing of baked products. However, information on OFSP puree-wheat flour composite bread consumer profile is limited. The aim of the current study was to investigate using a questionnaire consumer socio-demographics, knowledge, practices and attitude towards OFSP puree bread. A total of 1024 consumers were interviewed from Nairobi, Kiambu, Kajiado, Kisumu and Kakamega counties in Kenya. The OFSP bread is purchased mainly by female respondents (60.83%) consumers above 30 years old, who have a university education (79.3%), formally employed (93.10%), therefore, middle to high income earners. Before consumption, 42% of the consumers stored their bread in the refrigerator while 38% stored in the open, the rest in cupboards. Consumers agree that the OFSP bread could be a source of energy, vitamins, especially Vitamin A (93.8%) and minerals. The acceptance ratings of OFSP bread ranged from 7.37 to 7.65 on a 9-score hedonic scale therefore “like moderately”. There was a significant relationship between socio-demographics; knowledge about the bread and root and acceptance OFSP puree-wheat flour composite bread as indicated by the positive correlation coefficient ($p=< 0.01$). Consumers were willing to pay more for the OFSP bread based on potential nutritional benefits. Correlation analysis ($p=< 0.01$) significantly showed relationship between consumer demographics and willingness to pay for OFSP puree-wheat flour composite bread.

Key words: puree bread, knowledge, acceptance, preferences, consumers

3.1 Introduction

SUSTAIN (Scaling Up Sweetpotato Through Agriculture and Nutrition) project aims at increased production, processing, sale and consumption, scaling up the nutritional benefits of biofortified OFSP. A variety of processed products that contain OFSP as the main ingredient such as bread, buns, cookies, and juices are currently commercially available. SUSTAIN is also working with one of the chain supermarkets in Kenya on the production of commercial OFSP products and marketing strategies, with additional technical input from a private sector food technology firm, Euro Ingredients Limited (EIL). Organi Limited is a private company that processes OFSP puree and delivers to Tuskys for processing of bakery products such as bread, buns and scones (Muoki and Agili, 2015).

The quality of OFSP bread is defined by its characteristics that leads to consumer satisfaction and contentment. The quality of OFSP bread encompasses nutritional values, functional properties, sensory properties (appearance, texture, taste and aroma), chemical constituents and mechanical properties. Various parameters can be used to determine the quality of fresh commodities (Popper et al., 2004). The level of consumer acceptability is usually assessed by asking consumers to rate how much they like a product (Menon et al., 2015).

Food in its various forms has an essential role in all cultures in the world. Global discussions and debates relating to food associate food with human health (Worsley et al., 2015). Benefits from the consumption of functional foods are linked with different advantages to human health and quality of life (Grace et al., 2015). A product may not be accepted by consumers even if it has been proven to have health benefits and is not attractive to consumers or it’s sensory properties do not meet consumer expectations (Menrad, 2003). A novel food product will be acceptable to consumers if it is of quality, safe, nutritious and appealing. (Ahmed et al., 2010; House, 2016). Consumer satisfaction is very crucial for repeat purchase of any product (Hayat et al., 2010). Therefore, studying consumer acceptance of a product plays a very important role in the food industry. Consumer perception is an important aspect in defining food product quality and attributes (Nepote et al., 2009).

Consumer willingness to pay (WTP) can be estimated using open-ended question by asking the respondents to state the maximum amount they would be ready to pay, or close-ended, by offering a specific amount (dichotomous choice) and asking the respondents if they would be willing to pay or not. The consumer should be well informed about the novel product and its characteristics if one intends to use the open-ended format of getting consumers WTP (De Groote and Kimenju, 2008). Insufficient and therefore, lack of information will result to less consideration and value attached to such goods and therefore give unrealistic price estimate. (De Groote and Kimenju, 2008; Arrow et al., 2001). Close-ended questions are more realistic as they correspond with the real situation in the market and again they are easier on the respondent. Consumers are offered a particular price on the product, and after some negotiation they are faced with a decision to buy or not (De Groote and Kimenju, 2008). There have been reports of inefficiency of the single-bounded method which requires the individual to respond to one bid. This method is strategic in the respondents' interest to say ‘‘yes" if their WTP is equal or greater than the price asked, and ‘‘no" if otherwise (De Groote and Kimenju, 2008). The single-bounded method should involve a large sample size, otherwise, it will be statistically inefficient (Cooper et al., 2002; De Groote and Kimenju, 2008). The double-bounded contingent valuation (CV) method has replaced the single method to improve efficiency in WTP data collection. The respondent is offered a second bid, higher if they “yes” or lower if they said “no”. This method integrates more information about consumer’s WTP, providing better price estimates for the product with tight confidence intervals (Cooper et al., 2002). The purpose of this study was to profile consumers of OFSP puree-wheat flour composite bread, assessing their socio-demographic factors, knowledge and practices about OFSP and OFSP bread, product acceptance through sensory evaluation and their willingness to pay.

3.2 Materials and Methods

3.2.2 Study area

The study on consumer profiling for OFSP puree-wheat flour composite bread was carried out in one of the chain supermarkets in Nairobi, Kiambu, Kajiado, Kisumu and Kakamega counties where the bread is retailed. Nairobi, the largest city in East Africa and the capital of Kenya. The capital has around 3.1 million people and a 4% annual population growth rate (KNBS, 2015). Kiambu and Kajiado counties are centrally located and neighboring Nairobi County. Kisumu and Kakamega are on the lake side and Western regions of Kenya respectively.

3.2.3 Study type

The Counties were purposively preferred for the cross-sectional survey as they host the only chain of retail stores where the OFSP bread is retailed.

3.2.4 Study population

The survey targeted all consumers walking into the store with special consideration for those who had purchased the bread before. Consumers were randomly but systematically selected, picking every third consumer to participate in the survey. A questionnaire was used to determine consumer demographics, knowledge, purchase and after purchase practices, sensory evaluation and willingness to pay for the OFSP bread.

3.2.5 Sample size determination for consumer profiling

A list of the chain supermarkets retail stores where the OFSP puree-wheat flour composite bread is retailed was generated. About 50 consumers were targeted from each store.

3.2.6 Pre-testing

Questionnaires for consumer bread profiling were administered randomly to fifteen (15) staff at CIP offices before actual fieldwork to assess the relevance of the questions and subsequently make necessary modifications to ensure collection of reliable and valid data.

3.2.7 Data Collection Tools

A questionnaire was developed to assess the knowledge, attitudes towards food safety and quality, acceptance and willingness to pay for OFSP puree-wheat flour composite bread.

Questionnaire design

The Open Data Kit (ODK) set of tools was used to author, field, and manage mobile data collection. The XLS Form was built and data collected on a mobile device. The filled form was uploaded to the server for aggregation and analysis.

The questionnaire consisted of four sections: demographics, knowledge and practices of OFSP and OFSP products, sensory evaluation and willingness to pay. Demographic questions included gender, age, place/region grown, highest level of education attained, employment status and average monthly income. The knowledge section enquired if consumers were aware about the OFSP root, bread and nutritional benefits derived from the bread. If the consumer had purchased the bread before, they were asked about their purchase and after-purchase practices including how often they made OFSP bread purchases, loaves per purchase, if they checked the expiry date, time of purchase, storage conditions and how long the bread remained in storage. For sensory evaluation, the OFSP puree-wheat flour composite bread was displayed, covered with a clear cling foil and offered to the consumers. The consumers were asked to rate how much they liked the smell, color, taste, texture and after-taste of the OFSP bread on a nine-point hedonic scale where 1=dislike extremely and 9=like extremely. On willingness to pay, consumers were first asked whether they were willing to pay for OFSP bread at the current price. When they answered ‘‘yes”, they were offered a higher bid, a 10% premium of the current price. If the consumer agreed to pay, a higher bid of 30% and 50% was offered until the consumer responded “no”. Alternatively, if the consumer rejected the offer to pay for the OFSP bread at the current price, a discount of 10%, 30% and 50% was offered until they said “yes”.

3.2.8 Questionnaire administration

The survey was done in August 2016 with assistance from two prior trained enumerators. The questionnaire was administered in either English or Swahili. The survey employed a range of closed questions where the respondent agreed “yes” or disagreed “no” or ranked opinions on a scale for sensory evaluation section. Consumers were asked if they would like to take part in a survey and were informed on how to do the test. Information about ingredients used to make the OFSP bread was given to the consumers. A total of 1024 consumers were interviewed from Nairobi, Kiambu, Kajiado, Kisumu and Kakamega Counties.

3.2.9 Data Analysis

Statistical analysis was conducted in SPSS 20 to assess the effect of demographic factors on knowledge, attitude practices, sensory evaluation and willingness to pay. Spearman’s correlation test was conducted to measure associations and differences in proportions between groups. Statistical significance was set at p-value < 0.01.

3.3 Results and Discussion

3.3.1 Consumer demographics

Consumers knowledge, attitude and practices are influenced by various demographic factors such as background, age, gender, education and income level. The OFSP puree-wheat flour composite bread is purchased by mostly female respondents (60%), consumers aged above 30 years, having completed their university education (79%), formally employed (93%) and hence middle to higher income earners (< USD 500 per month), from Nairobi, Western and Central regions of Kenya as shown in Table 3.1.

Table 3.1 Consumer demographics

Consumer Demographic	Total N=1024	Purchased OFSP bread n=174
GENDER	**Percentage**	
Female	58.40	60.34
Male	41.60	39.66
AGE		
<20 years	5.40	2.87
21-30	26.80	17.24
31-40	32.30	27.59
41-50	24.10	31.61
>50 years	11.40	20.69
PLACE GROWN		
Nairobi	21.10	20.69
Western Region	21.20	16.09
Eastern region	7.20	10.34
Central Region	15.90	20.69
Rift Valley	9.50	11.49
Coast	2.70	4.60
North Eastern	2.90	5.75
Nyanza	18.80	9.77
EMPLOYMENT		
Formal employment	83.30	93.10
Unemployed	16.70	6.90
EDUCATION		
Incomplete primary	0.90	0.57
Complete Primary	2.00	1.15
Incomplete Secondary	5.80	4.02
Complete Secondary	13.80	6.32
Incomplete College/University	12.00	8.05
Complete College/University	65.20	79.31
INCOME LEVEL		
USD 100 - USD 200	14.40	9.09
USD 200 - USD 300	17.20	21.59
USD 300 - USD 400	15.10	11.36
USD 400 - USD 500	22.70	26.14
>USD 500	27.70	31.82

Table 3.2 summarizes the Spearman correlation analysis between the identified demographic profiles of the respondents and their knowledge about the OFSP root, bread, Vitamin A and their after-purchase practices. The correlation coefficient (r) values ranged from -1 (perfect negative correlation) to +1 (perfect positive correlation) (Juan et al., 2011). The demographic profile of the respondents showed a weak positive correlation to the knowledge about the root and OFSP bread, OFSP bread purchase and Vitamin A as indicated by the correlation coefficient in Table 3.2.

Table 3.2 Correlation values showing the relationship between consumer demographics and knowledge

Demographic profile	Knowledge-OFSP root	Knowledge-OFSP bread	Vitamin A	OFSP bread Purchase	Check Expiry date	Bread Storage Condition
Gender	0.059*	0.008	0.052*	0.018*	0.052*	0.034*
Age	0.143*	0.094*	0.025*	0.233*	0.154*	0.363*
Place grown	0.075	-0.028	0.040*	-0.109	0.053*	0.116*
Education	0.134*	0.134*	0.027*	0.177*	0.094*	0.069*
Monthly average Income	-0.050	0.051*	0.078*	0.263*	0.171*	0.266*

** Correlation is significant at the 0.01 level (2-tailed).*

Female respondents were most informed about the root (61%), bread (61%), Vitamin A (59%) also made majority of the purchasers (60%). Consumers from Western and Nyanza regions of Kenya were better informed of the OFSP root than the OFSP puree-wheat flour composite bread and it's benefits as a source of Vitamin A, as shown by the positive correlation coefficient ($r = 0.075$), compared to consumers from other regions of the country as most cultivation of the root takes place in these regions. The distribution of OFSP bread is strongly geographically determined within Nairobi hence the negative correlation coefficient ($r = -0.028$).

Being educated significantly ($p < 0.01$) and positively correlated with consumers' knowledge on the OFSP root and bread ($r = 0.134$) with 92% respondents with a university and secondary education knew about the root, and 94% knew about the bread. positive correlation coefficient exhibited all through. Studies have shown that duration or level of education is positively correlated to nutrition knowledge and those with high levels of education are more likely to demand quality products (Worsley et al., 2015). About 94% of those who knew about the OFSP root were also knowledgeable about Vitamin A. The level of income negatively correlated ($r = -0.050$) with the knowledge of OFSP root, the higher the income level, the less aware the consumer was about the root while the high-income earners were more aware about the OFSP puree-wheat flour composite bread, hence the significant ($p < 0.01$) positive correlation coefficient ($r = 0.051$).

3.3.2 Consumer After-Purchase Practices

Respondents who had purchased the bread before were one hundred and seventy-four (174). Consumers mostly buy the bread in the evening after work. During this time the bread will have been on the shelves for a few hours. Consumers are keen to check the expiry date of the OFSP puree-wheat flour composite bread regardless of their demographic profile hence the positive coefficient of correlation as shown in Table 3.2. Consumers purchased one to two loaves depending on their family size. The respondents who had families, 96% said they gave their children the OFSP bread for breakfast or a snack. This assures that the children have a source of Vitamin A. Consumers agree that the OFSP bread could be a source of energy, vitamins, especially Vitamin A (94%), and minerals and therefore, they were aware about the nutritional benefits from the bread.

After purchase, 42% of the consumers stored their bread in the open while 38% stored in the refrigerator, the rest stored in cupboards. There was a strong positive correlation between the storage condition of the bread and the age, income, place grown and a weak positive correlation due to the highest level of education attained and gender. Consumption of the bread happens mostly during breakfast, just less than a day after purchase.

3.3.3 Sensory Analysis

Addition of the orange fleshed sweetpotato puree-wheat flour composite to bread baking significantly ($p < 0.01$) affected the quality of the bread as shown in Figure 2.

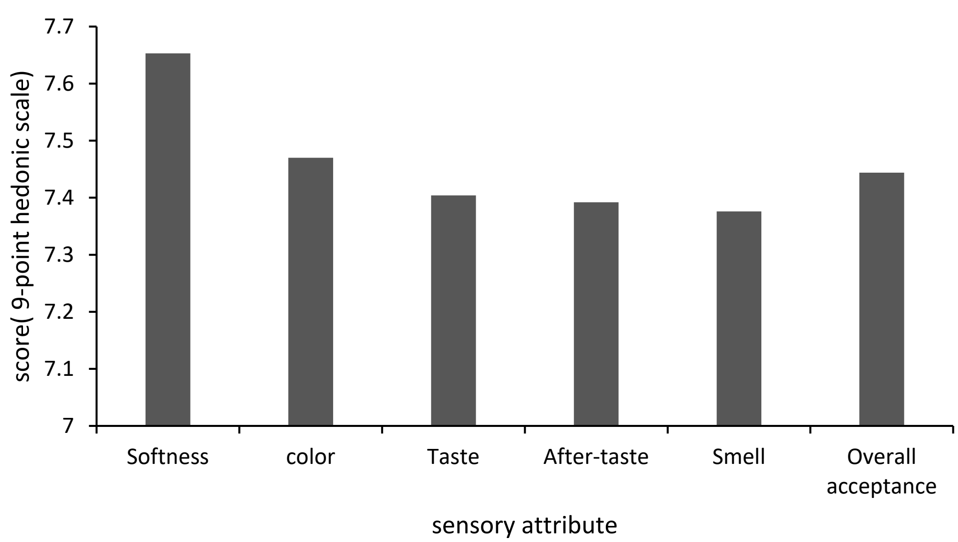

Figure 3.1 Sensory acceptance of OFSP bread

Consumers commended the bread's soft texture which scored an average 7.65, the most highly scored parameter, implying that it was the most accepted quality attribute. The softness of the bread was significant (p=< 0.01) and correlated positively with the highest level of education acquired. The color and taste of the OFSP puree-wheat flour composite bread scored 7.47 and 7.40 respectively. The after-taste of the OFSP bread scored least with an average of 7.39 due to complains of slight astringency. The flavor of the bread was moderately liked and hence acceptable with an average score of 7.37. Consumers approved the aroma of the sweetpotato in the bread. However, the flavor and after-taste of the OFSP bread scored least on the quality attributes as consumers associated these with some astringency. The overall acceptability score of OFSP puree-wheat flour composite bread was an average of 7.44 and therefore the bread was "moderately like" and hence accepted by the consumers.

Table 3.3 summarizes the relationship between consumer's demographics, knowledge, practices and WTP of the OFSP puree-wheat flour composite bread and their sensory acceptance for the bread. A weak negative relationship exists between gender and sensory attributes of OFSP bread. There was a significant relationship between consumer demographics; age and education attainment, knowledge about the bread and root and acceptance of the puree-wheat flour composite bread as indicated by the positive correlation coefficient. This is to indicate these factors influenced consumers' bread acceptance. There was a strong positive correlation coefficient between consumer acceptance of the sensory attributes of OFSP puree-wheat flour composite bread and their purchase practices as well as their willingness to pay. This implies that consumers were willing to pay more and make purchases of the OFSP puree-wheat flour composite bread based on high preference of its sensory attributes. The OFSP bread was liked by 83% of respondents. The predominant sensory attributes for consumer’s acceptance were softness, color and taste which had the most impact on the acceptability of the product

Table 3.3: Correlation values showing relationship between respondents' demographics and sensory attributes of OFSP bread

Demographic profile	**Softness**	**Color**	**Taste**	**After-taste**	**Smell**	**Overall**
Gender	-0.085	-0.060	-0.043	-0.051	-0.034	-0.032
Age	0.009	0.024	0.028	0.019	0.022	0.071
Childhood	0.001	-0.003	-0.011	-0.004	0.049	0.014
Education	0.011	0.009	0.023	0.006	0.004	0.004
Monthly average Income	0.006	0.003	-0.014	-0.004	0.009	0.037
Knowledge - OFSP root	0.102*	0.096*	0.155*	0.117*	0.138*	0.130*
Knowledge -OFSP bread	0.058	0.007	0.048	0.056	-0.005	0.064
OFSP bread Purchase	0.193*	0.126*	0.191*	0.233*	0.180*	0.208*
Willingness to pay	0.181*	0.173*	0.190*	0.195*	0.170*	0.238*

***Correlation is significant at 0.01 level (two-tailed).**

3.3.4 Willingness to pay

From this study, the place where the spent most of their childhood influenced their decision on their willingness to pay (Table 3.3). Consumers from Nairobi, Kisumu and Kiambu counties were willing to pay more if the price was increased by 10%, while respondents from Kakamega and Kajiado preferred a 10% discount. The level of education negatively related to consumers' willingness to pay, with 66.3% respondents who had completed their university education being less willing to pay if the price of the bread was increased by 10%. The higher the income level, the less the consumers were willing to pay for the bread if there was a 10% increase on the price of the bread. Income and education have been shown to have a clear negative effect on price elasticity (De Groote and Kimenju, 2008).

The level of income, education, gender, and ethnic background have been shown to have an effect on consumers' willingness to pay (De Groote and Kimenju, 2008). Consumers (83%) were willing to pay for the OFSP bread, and accepted the current price of the OFSP puree-wheat flour composite bread. More than half (61%) of the consumers who were willing to pay for the bread at the standard price (Ksh 50) were willing to pay more if the price of the bread was increased by 10%. However, only 4.6% of the these were willing pay for the bread if it's price was increased by 30%, with condition that the bread be better packaged and the nutritional benefits well illustrated. This is as shown in Table 3.4.

Table 3.4 Consumers' Willingness to Pay for OFSP puree-wheat flour composite -Wheat Composite bread

Consumers WTP	WTP Ksh 50	WTP (10% increase)	WTP (10% decrease)
Yes	83%	61%	5%
No	17%	22%	12%

Consumers reiterated that a higher discount on the bread would be questionable regarding the quality of the bread so 16.6% of the respondents were willing to pay for less than the standard price for the 400g bread. Female respondents (58.1%) were more willing to pay even after an increase of the 10% on the OFSP bread than the male respondents.

3.4 Conclusion

Consumers' knowledge, attitude and practices are influenced by various demographic factors as revealed by the correlation analysis. Age, gender, education attained and income level and consumers' willingness to pay for OFSP puree-wheat flour composite bread have significant relationship with acceptance. The sensory attributes of the OFSP puree-wheat flour composite bread were "moderately liked" and hence acceptable to the respondents. Consumers were willing to pay more for the bread based on their knowledge on potential health benefits derived from it. This indicates that consumers favor innovation in food processing and fortification, therefore very willing to try it.

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CHAPTER FOUR

4.0 Physiochemical Properties and Shelf-Life of Orange Fleshed Sweetpotato (OFSP) Puree-wheat flour composite Bread

Abstract

Diversified utilization and fortification of Orange Fleshed SweetPotato (OFSP) into novel products ensures availability of pro-vitamin A in the diet. However, substitution of wheat during novel development of bread affects its physiochemical properties hence, its shelf-life. The purpose of this study was to determine the shelf-life of OFSP bread in comparison to white bread. The OFSP puree-wheat flour composite bread and white bread were stored at 7, 20℃, 25℃ and 30℃ and their moisture content, water activity, volume, texture, color, microbial load and β-carotene content analyzed, baseline and end line for a period of seven (7) days. The moisture content, crumb and crust color of the bread significantly ($p<0.05$) decreased with increase in storage temperature and time. Increase in water activity and microbial load was significantly ($p<0.05$) high in white bread than in OFSP puree-wheat flour composite bread. The initial β-carotene content of OFSP puree-wheat flour composite bread ranged between 0.0498 and 0.0532 mg/100g. These significantly ($p<0.05$) decreased after storage, ranging between 0.0263 and 0.0277 mg/100g due to thermal degradation. β-carotene was non-detectable in white bread. Specific volume of white bread was significantly ($p<0.05$) high than that of the OFSP puree-wheat flour composite bread. Refrigeration significantly ($p<0.05$) increased crumb firmness, chewiness, crumb cohesiveness, gumminess while incubation temperature caused a decrease in resilience. The white bread and OFSP puree-wheat flour composite bread showed spoilage on the fourth and sixth day respectively for storage above 20℃, 25℃ and 30℃. Therefore, OFSP puree-wheat flour composite bread had a longer shelf-life than white bread. Storage at 7℃ preserved the quality of the bread, hence recommended.

Keywords: puree bread, β-carotene, water activity, microbial, texture, color

4.1 Introduction

The orange fleshed sweetpotato (OFSP) is an essential source of pro vitamin A, energy and nutrients such as carbohydrates, minerals, and also adds to the color, natural sweetness, flavor, and dietary fiber of processed foods (Ijah et al., 2014). In Western and Nyanza regions of Kenya, production of OFSP has increased, an initiative of Sweet Potato for Health Initiative (SPHI) and Sweet Potato Action for Security and Health in Africa (SASHA). OFSP is used to curb Vitamin A deficiencies in these regions through its incorporation into the diet at household level. The processing and utilization of OFSP root at domestic level was until recently limited to boiling and roasting. OFSP value addition at household level currently includes its incorporation during chapatti, mandazi, crackies, doughnuts, juice, salad and vegetable relish preparation (Stathers et al., 2013). Surplus in OFSP production has led to commercialization, so that the OFSP is being used as an ingredient in formulation of baked products at industrial level (Ijah et al., 2014). Processing of OFSP at industrial level involves use of OFSP puree as an ingredient in baking of bread, buns and scones with up to 30- 50% wheat substitution (Muoki and Agili, 2015; Stathers et al., 2013). Using OFSP puree in processing of OFSP products such as bread and buns is a sustainable and cost-effective way of increasing Vitamin A intake (Yusuf et al., 2015).

Bread, like any other food, starts to deteriorate immediately after baking due to chemical and physical changes that are described in the staling process (Gray and Bemiller, 2003). Novel baking technologies have been used with attempts to extend the shelf-life of bread and improve on the flavor and texture to better respond to the dynamic market demands (Corsetti et al., 2007).

Baked products have their water activity at (0.75-0.95) and hence spoilage will be due to xerophytic molds (Smith et al., 2012). Baking temperatures destroy these molds. However, re-contamination may arise from the environment and surfaces during the cooling, slicing, and wrapping or packaging procedures (Jideani and Vogt, 2015). Fungal growth on the loaf in addition to being unappealing, results to formation of off-flavors and synthesis of mycotoxins and allergic compounds which are hazardous when consumed (Zhao et al., 2015). Water activity is a better indication of food perishability than moisture content as it is closely associated with other food constituents. Chemical reactions and microbial growth occur in high levels of water activity (Nielsen, 2010). Ayub et al., (2003) reported that reducing water activity below 0.7 would retard microbial spoilage, however, spoilage still occurs due to other deteriorative factors such as storage temperatures and oxidation-reduction potential.

The quality of bread depends on the ingredients used during baking (Onyango, 2016). Substitution or replacement of wheat flour influences the textural, nutritional and organoleptic and hence the shelf-stability of the bread. This study explores the physiochemical properties of OFSP bread and hence establish its shelf-life by investigating the effect of storage temperature on moisture content, water activity, microbial growth, color, carotenoids content, texture and volume of OFSP puree-wheat flour composite and white bread, consequently, the quality and shelf-stability considering the handling methods by consumers of the bread. This is important to the food industry as consumers not only demand for healthy and nutritious foods but also a safe product with an extended shelf-life.

4.2 Materials and Methods

Sample Collection

The bread samples were collected fresh from the oven, from the only processing retail outlet bakery in Nairobi. The analysis was done on the first day (baseline) and then the samples were stored at 7ºC, 20ºC, 25ºC and 30ºC and subsequently analyzed end line. Analysis involved:

4.2.1 Determination of water activity

Water activity was measured using a water activity meter Aqua Lab Series 4TE from Decagon Devices, Inc. (NE Hopkins Ct. Pullman, WA, USA). The water activity meter was calibrated using the verification standards (a_w = 0.765 and a_w = 0.500) at 25 °C and the values were determined to be within the required range of ±0.001. The water activity of the bread samples was measured in triplicates (Juan-Borras et al., 2016).

4.2.2 Determination of Moisture Content

Moisture content was determined in triplicates using the Mettler Toledo HE53 Halogen Moisture Analyzer (Switzerland). The sample was weighed, heated using halogen to evaporate all moisture, and then the moisture content of the sample was calculated based on the weight loss and displayed real-time on the moisture balance digital display.

3.2.3 Microbial analysis

Total viable bacterial counts and fungal (yeast and molds) were analyzed in both the OFSP and white bread samples as described in AOAC (2012). Bread samples were prepared by homogenizing 10g in buffered peptone water and then used 1ml of this to make subsamples decimally diluted up to four (4) dilutions. Pour plate method was used during plating (Jay et al., 2005). This was done in triplicates. The TVC plates were incubated at 30 ℃ for four (4) days, while those of yeast and mold were incubated at 25℃ for 5 days

4.2.4 Carotenoid analysis

Determination of carotenoids was done qualitatively using the Agilent Cary 60 UV-Vis Spectrophotometer and quantitatively using Waters HPLC (Massachusetts, United States) as described by Kurilich and Juvik (1999).

4.2.5 Bread crust and crumb color

Color determination was carried out on bread crumb and crust using Lovibond® LC 100 / SV 100 handheld spectrocolorimeter (England) and results were expressed in accordance with the Hunter Lab color CIE L*a*b space. The parameters determined were L* (light/dark) a* (=red/green), b* (blue/yellow) and C* (bright/dullness) (Mannuramath et al., 2015). The standard used in this study was bread color during baseline analysis.

4.2.6 Bread volume

Bread volume was determined by displacement method using bird millet as described in AACC, (2001). Specific volume was calculated as volume to weight ratio (cm^3/g) (Mannuramath et al., 2015).

4.2.7 Crumb firmness

Texture profile analysis was done using a texture analyzer (TA-XT2, Stable Micro Systems, Godalming, United Kingdom) equipped with a 36-mm Perspex cylinder probe along with a 50-kg load cell according to AACC Method 74-10A (2000).

4.3 Results and Discussion

4.3.1 Moisture content of OFSP and white bread

The moisture content of OFSP puree-wheat flour composite bread ranged from 30.20% to 33.38% and 29.02% to 30.15% for white bread. Storage conditions had a significant ($p<0.05$) effect on the moisture content of both samples as shown in Table 4.1.

Table 4.1: Moisture content and water activity in OFSP and white bread

Parameter		**Moisture content**				**Water activity**			
Sample	Storage Temperature	**7°C**	**20°C**	**25°C**	**30°C**	**7°C**	**20°C**	**25°C**	**30°C**
OFSP puree-wheat flour composite bread	Baseline	33.88^{i}	31.89^{h}	30.55^{g}	30.20^{fg}	0.9361^{cd}	0.9296^{fg}	0.9260^{bc}	0.9254^{bc}
	End line	28.93^{cd}	29.81^{ef}	27.44^{ab}	29.45^{de}	0.9377^{de}	0.9338^{gh}	0.9362^{f}	0.9416^{hi}
White bread	Baseline	29.02^{cd}	30.15^{fg}	29.71^{ef}	29.69^{ef}	0.9248^{ef}	0.9206^{ab}	0.9273^{bcd}	0.9352^{a}
	End line	27.15^{a}	27.22^{a}	27.81^{b}	28.51^{c}	0.9290^{fgh}	0.9248^{bcd}	0.9457^{i}	0.9541^{fgh}

All values reflect mean counts. Values bearing different superscript letters in each row are significantly different ($p<0.05$)

There was a significant ($p<0.05$) decrease in moisture content of bread with increase in storage temperature. The significant differences in the same bread stored in different temperature is because a different sample was stored in different temperature setting. Studies by Gray and Bemiller, (2003) showed that bread stored at lower temperatures dried out fast, accelerating the rate of staling which is correlated with recrystallization of starch. Starch crystallization diminished with increase in storage temperature resulting to staling of bread. These findings agree with those of (Abu-Ghoush et al., 2007) who found that the moisture content significantly decreased after storage in refrigeration temperature so that the composite bread was firmer. There was a significant ($p<0.05$) decrease in moisture content of the bread with further increase in storage temperature due to the staling process (Gray and Bemiller, 2003) .

4.3.2 Water activity in OFSP and white bread

Statistical analysis showed significant differences ($p< 0.05$) in the initial water activity levels of the OFSP and white bread ranging between 0.9207 to 0.9320, respectively (Table 4.1). Storage temperature had a significant ($p< 0.05$) effect on the water activity so that an increase in water activity was recorded as seen in Figure 3. The white bread had significantly ($p< 0.05$) higher increase in the water activity than the OFSP bread. It is notable that the white bread had significant ($p< 0.05$) change in water activity level compared to the OFSP bread, favorable for mold growth (Abu-Ghoush et al., 2007). The decrease in water activity in the OFSP puree-wheat flour composite bread was possibly due to concentration of sugars attributed to the use of OFSP puree (Jay et al., 2005). According to Nielsen (2010), the less available the water activity, the fewer the chemical reactions and microbial growth that cause decomposition.

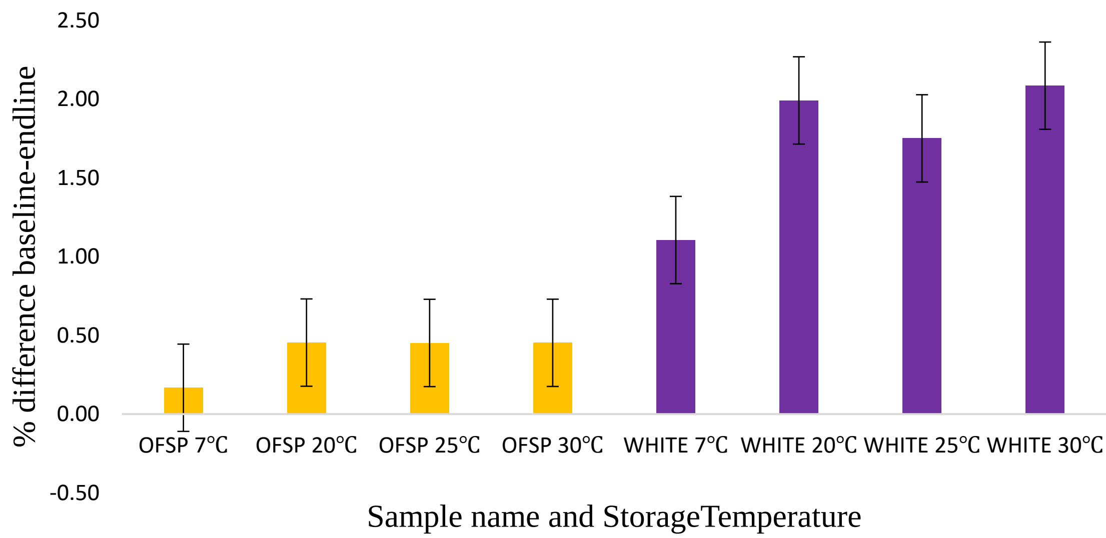

Figure 4.1 Changes in water activity in OFSP and white bread

4.3.3 Microbial load in OFSP and white bread

On the first day of the experiment, there were no colonies observed for total microbial and fungal counts for both the OFSP and white bread. This indicates that the loaves of bread were not contaminated, as baking temperatures are effective in destroying contaminants from the ingredients and general handling. However, contamination could arise depending on how the bread is handled after baking, during cooling to packaging, distribution and storage conditions. No microbial counts were observed for OFSP and white bread after storage at 7°C and 20°C. Total microbial counts were 2.88×10^3 and 3.24×10^3 CFU/g for OFSP bread stored at 25°C and 30°C respectively at the end line analysis. Refrigeration preserved the white bread hence no microbial growth after analysis. Total microbial counts for end line analysis from white bread were 3.68×10^3, 3.93×10^3 and 4.25×10^3 CFU/g in storage at 20°C, 25°C and 30°C respectively as shown in Table 4.2.

Table 4.2: Microbial load in OFSP and white bread

Sample	*Storage temperature*	*TVC*		*Yeast and mold*	
Microbial analysis		Baseline	End line	Baseline	End line
OFSP puree-	7°C	No growth	No growth	No growth	No growth
wheat flour	20°C	No growth	No growth	No growth	No growth
composite	25°C	No growth	2.88x 10^3 CFU/g	No growth	No growth
bread	30°C	No growth	3.24x 10^3 CFU /g	No growth	No growth
White bread	7°C	No growth	No growth	No growth	No growth
	20°C	No growth	3.68 x 10^3CFU /g	No growth	2.19x10^3 CFU /g
	25°C	No growth	3.93 x 10^3 CFU/g	No growth	3.94x10^3 CFU/g
	30°C	No growth	4.25x 10^3 CFU/g	No growth	3.97x 10^3 CFU/g

This significant difference ($p<0.05$) in total counts may have been due to moisture and water activity levels (Ayub et al., 2003) and also the difference in amount of mold growth inhibitors used.

There was no fungal growth on the OFSP bread during baseline and end line analysis. The amounts of mold inhibitors used during baking were effective in preventing mold growth. White bread stored in refrigeration temperatures did not have fungal growth throughout the storage period. Storage conditions had a significant effect on fungal growth in the white bread where colonies of 2.19 x 10^3, 3.94 x 10^3 and 3.97 x 10^3 CFU/g were observed in white bread stored at 20°C, 25°C and 30°C, respectively. This is beyond the acceptable limit for Kenya Standards for bread that allows for 100 CFU/g (KS 172:2010). The increase in microbial population in the white bread could be due to the moisture content and water activity levels of the white bread which were significantly ($p<0.05$) higher than in the OFSP puree-wheat flour composite bread. Favorable water activity levels are known to provide favorable conditions for microbial growth (Nielsen, 2010).The use of mold inhibitory preservatives was also contributory to absence of yeast and molds. Microbial growth on white bread was visible from the fourth day and sixth day for the OFSP puree-wheat flour composite bread.

4.3.4 Total carotenoids in OFSP and White bread

Total carotenoids in the OFSP and white bread were initially 0.0574 and 0.0032 mg/100g respectively (Table 4.3).

Table 4.3: Carotenoid content mg/100g in OFSP and white bread by spectrophotometric method

Storage Temperature		**7**°C	**20**°C	**25**°C	**30**°C
OFSP bread crumb	Baseline	0.0474^{f}	0.0520^{g}	0.05183^{g}	0.0523^{g}
	End line	0.0425^{e}	0.0285^{d}	0.0260^{cd}	0.0289^{d}
OFSP bread crust	Baseline	0.0521^{g}	0.0542^{g}	0.0502^{fg}	0.0523^{g}
	End line	0.0393^{e}	0.0269^{cd}	0.0262^{cd}	0.0237^{c}
White bread crumb	Baseline	0.0032^{a}	0.0061^{ab}	0.0059^{ab}	0.0087^{b}
	End line	0.0027^{a}	0.0024^{a}	0.0022^{a}	0.0027^{a}
White bread crust	Baseline	0.0025^{a}	0.0027^{a}	0.0054^{ab}	0.0083^{b}
	End line	0.0025^{a}	0.0022^{a}	0.0023^{a}	0.0027^{a}

All values reflect mean counts. Values bearing different superscript letters in each row are significantly different ($p<0.05$)

Carotenoid content was determined on wet weight basis. Refrigeration preserved the carotenoids and hence the minimal loss in comparison to storage at higher temperatures. Carotenoids deteriorate when subjected to heat treatment (thermal degradation) (De Moura et al., 2015). Carotenoids in the white bread were possibly xanthophyll, lutein, zeaxanthin and β-cryptoxanthin (Bhatnagar-Panwar et al., 2013). OFSP bread had significant ($p<0.05$) levels of total carotenoids, mostly β-carotene as detected by HPLC method, that ranged between 0.0498 and 0.0532 mg/100g. β-carotene was non-detectable in the white bread.

β-carotene levels in the OFSP bread were significantly ($p<0.05$) lower during the end line analysis depending on the temperature of storage as shown in Figure 5.

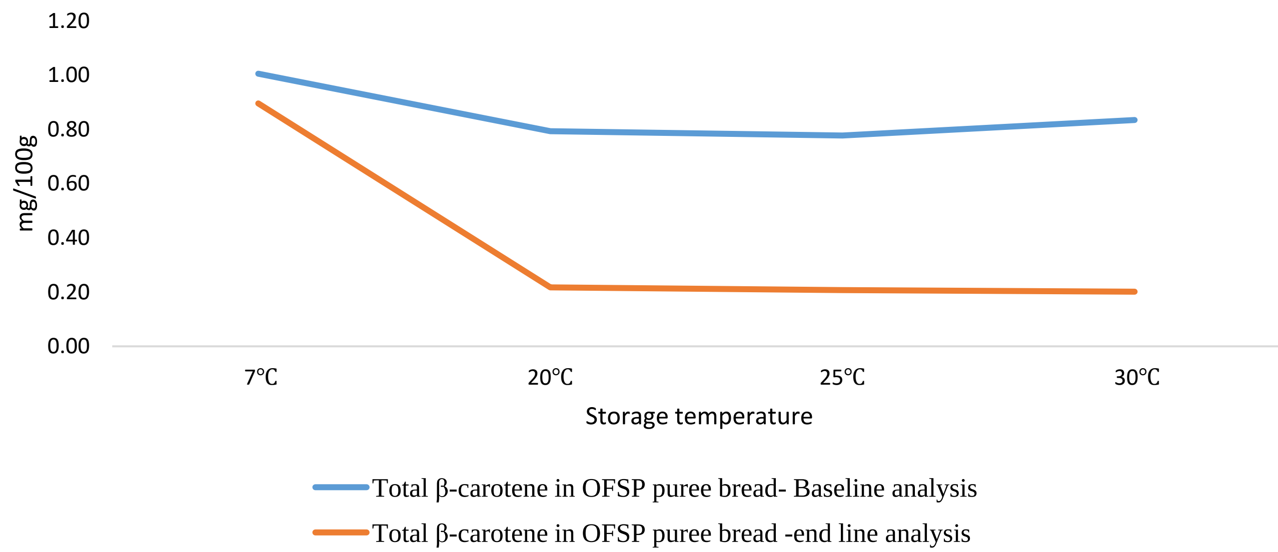

Figure 4.2 β -carotene content in OFSP bread

Initially, β-carotene amounts ranged between 0.0498 to 0.0532 mg/100g. These significantly ($p<0.05$) decreased to range between 0.0261 and 0.0277 mg/100g after storage. Refrigeration temperature preserved β-carotene levels and hence the minimal loss of the carotenoids. There was no significant ($p<0.05$) change during end line analysis for storage at temperatures at 20℃ and 25℃. Storage of bread at a temperature of 20℃ and above is detrimental to carotenoids. This is because carotenoids are prone to thermal deterioration (Yusuf et al., 2015; De Moura et al., 2015).

4.3.5 OFSP and white bread crust and crumb color

Increase in storage temperature resulted to a significant ($p< 0.05$) decrease in the L* (lightness/darkness) of both OFSP and white bread crumb and crust. Refrigeration temperatures did not cause significant changes($p> 0.05$) on the L* values of OFSP and white bread crumb and crust as in Tables 4.3 and 4.4. The white bread crumb became darker after storage at 30℃ after 7 days with a L* values significantly ($P< 0.05$) decreasing from 77.33 to 20.23. The difference in luminosity was because of mold growth on the white bread. Increase in storage temperature resulted to a significant ($p< 0.05$) decrease in the luminosity of the white bread crust and crumb. There was no significant difference ($p>0.05$) in the luminosity of the OFSP bread crust and crumb due to differences in storage temperature after 7 days. This is due to absence of mold growth on the OFSP bread. Luminosity in the white bread crust significantly ($p< 0.05$) decreased after 7 days' storage at 25℃ and 30℃ (from 63.63 to 57.23). Storage of white bread at 20℃ had a significant effect on the L*values of the crust. The crust of the white and OFSP bread was brown in color due to maillard reactions: the reaction of reducing sugars with free amino acids in the proteins (Aguilar et al., 2015)

Storage temperature had a significant effect on the redness, a* values on the OFSP bread crumb and crust values so a decrease was noted to indicate green color. Storage of the white bread at 30℃ resulted to a significant increase ($P < 0.05$) in a* values, so the bread crumb and crust was indicated a red color due to mold growth.

A significant ($p<0.05$) decrease in the b* values was observed in both the OFSP and white bread crumb after the storage period in the various temperature as recorded in Table 4.4. White bread stored at 30℃ was most affected so that it was bluer. This can be explained by presence of mold on the crumb and crust.

C* defines the brightness or dullness of a luminous object. There was no significant difference ($p>0.05$) in the brightness of OFSP with respect to storage temperature at 20℃, 25℃, and 30℃. Storage at refrigeration temperatures (7℃) had a significant decrease in the C* value so the OFSP bread crumb was duller. The crumb of the white bread was initially brighter. There was no significant difference ($p>0.05$) for storage at 7℃ and ℃. Storage at 30℃ had significant effect, decreasing the C* value to (5.43) so that the white bread crumb was dull.

Table 4.4: Color of OFSP and white bread crumb

Sample		OFSP bread				White bread			
	Storage Temperature	**7°C**	**20°C**	**25°C**	**30°C**	**7°C**	**20°C**	**25°C**	**30°C**
L	Baseline	73.67^{d}	73.80^{d}	73.83^{d}	73.43^{d}	78.47^{f}	77.07^{e}	77.00^{e}	77.33^{e}
	End line	70.53^{c}	71.47^{c}	72.70^{d}	66.80^{b}	78.70^{f}	71.37^{c}	71.60^{c}	20.23^{a}
a	Baseline	5.93^{fg}	5.83^{fg}	6.33^{fg}	6.53^{g}	-1.67^{bc}	-0.57^{d}	-1.27^{cd}	-1.40^{cd}
	End line	4.37^{e}	5.57^{f}	6.60^{g}	6.60^{g}	-1.20^{cd}	-2.47^{b}	-3.47^{a}	4.57^{e}
b	Baseline	31.70^{fg}	32.27^{g}	31.53^{fg}	31.17^{fg}	14.50^{d}	12.57^{b}	12.57^{b}	12.57^{b}
	End line	27.33^{e}	32.13^{g}	30.60^{f}	30.63^{f}	13.17^{bc}	14.57^{d}	14.57^{cd}	0.57^{a}
C	Baseline	31.90^{g}	32.23^{g}	31.97^{g}	32.07^{g}	14.60^{e}	12.33^{b}	13.63^{cde}	12.70^{bc}
	End line	27.40^{f}	32.70^{g}	31.40^{g}	31.63^{g}	13.33^{bcd}	13.23^{bcd}	14.43^{de}	5.43^{a}

All values reflect mean counts. Values bearing different superscript letters in each row are significantly different ($p<0.05$)

Table 4.5: Color of OFSP and White bread crust

Samples		OFSP bread				White bread			
	Temperature	**7°C**	**20°C**	**25°C**	**30°C**	**7°C**	**20°C**	**25°C**	**30°C**
L	Baseline	50.17^{b}	49.90^{b}	50.33^{b}	49.53^{b}	61.90^{e}	60.43^{d}	63.23^{f}	63.63^{f}
	End line	48.47^{a}	48.30^{a}	48.37^{a}	48.40^{a}	65.33^{g}	59.90^{d}	56.50c	57.23^{c}
a	Baseline	17.07^{gh}	17.03^{gh}	16.47^{fg}	17.63^{h}	15.13^{cde}	15.13^{de}	14.43^{bc}	12.77^{a}
	End line	15.83^{ef}	17.47^{h}	16.73^{g}	15.47^{e}	12.53^{a}	14.53^{bcd}	14.27^{b}	15.60^{e}
b	Baseline	29.83^{cd}	30.17^{cdef}	31.00^{dfg}	29.83^{cde}	34.67^{k}	33.40^{j}	32.70^{hij}	32.90^{ij}
	End line	27.57^{a}	31.10^{fg}	27.40^{a}	28.03^{a}	31.77^{ghi}	31.60^{gh}	29.60^{bc}	28.57^{ab}
C	Baseline	34.53^{def}	30.90^{ab}	34.10^{cdef}	31.87^{bc}	35.83^{efg}	35.83^{efg}	35.47^{defg}	37.67^{g}
	End line	29.20^{a}	35.27^{defg}	33.33^{bcde}	31.13^{ab}	34.57^{def}	34.47^{def}	32.90^{bcd}	34.50^{def}

All values reflect mean counts. Values bearing different superscript letters in each row are significantly different ($p<0.05$)

4.3.6 OFSP and white bread Volume

The specific volume of white bread was found to be significantly ($p<0.05$) higher than that of the OFSP puree-wheat flour composite bread as shown in Table 4.6.

Table 4.6: Specific Volume of OFSP and white bread

Bread/Storage Temperature	7°C	20°C	25°C	30°C
OFSP puree-wheat flour composite bread	3.989^{a}	3.925^{a}	3.941^{a}	3.863^{a}
White bread	4.526^{bc}	4.592^{c}	4.429^{b}	4.412^{b}

All values reflect mean counts. Values bearing different superscript letters in each row are significantly different ($p<0.05$)

The specific volume increased with increase in storage temperature. The specific volume of OFSP puree-wheat flour composite bread was significantly lower ($p < 0.05$) ranging between 3.863 and 3.989 cm^3/g while that of the white bread ranged between 4.412 and 4.592 cm^3/g. The lower specific volume in OFSP puree-wheat flour composite bread is owed to the reduced extensibility of wheat gluten due to its partial substitution with OFSP puree (Tsai et al., 2012;Gewehr et al., 2016). The reduction in volume was due to dilution of gluten, and physical interactions and chemical reactions between fiber components, water, and gluten. Bread volume results from both yeast gassing power and the ability of the gluten matrix to stretch and retain gas. Due to the fiber effect, the air "escapes," leaving the bread denser with a smaller volume (Gewehr et al., 2016). This aspect influences the texture and volume of the product over the shelf life. This can be countered by addition of gluten or gelatinized starch to the list of OFSP puree bread ingredients to improve the expansion of the pore walls of baked bread for sustainability of gas pressure produced during fermentation and baking (Tsai et al., 2012).

4.3.7 OFSP and White Bread Texture

Texture analysis results showed a general increase in hardness, springiness, cohesiveness, gumminess after storage in the various temperatures in both the white and OFSP bread.

It has been reported that refrigeration temperatures increase the process of crystallization of amylose and amylopectin matrix which contribute to overall bread texture and consequently staling. Bread hardness was due to interactions between gluten and fibrous materials and also due to moisture loss. (Feili et al., 2013;Gray and Bemiller, 2003).

OFSP puree-wheat flour composite bread recovered from its un-deformed condition (springiness) after the deforming force was removed at a significantly high rate ($p<0.05$) as compared to the white bread. This could be attributed to amounts of gluten added in the mixing of OFSP dough which led to an increase in elasticity and stretchability of the dough used.

High values of cohesiveness are desirable in bread as this infers to less forces required for disintegration, during mastication (Onyango et al., 2010). There was no significant difference ($p>0.05$) in cohesiveness in the OFSP and white bread at the beginning of the experiment. Refrigeration of the bread resulted to a significant increase in cohesiveness as compared in storage at 30°C**.** The OFSP bread was significantly affected by storage conditions at 30°C than the white bread.

Increase in gumminess was significantly ($p<0.05$) high after storage at refrigeration temperatures than in storage at 30°C. This could be attributed to the increase in hardness caused by crystallization of amylopectin and amylases in both the OFSP and white bread. Gumminess in OFSP bread was significantly ($p<0.05$) high and different from white bread due to dilution of the soluble proteins of the protein matrix embedded in the starch granules leading to reduced interference with the starch.

Chewiness is a derived component of texture, a product of hardness, springiness and cohesiveness and usually represents the energy required to chew mostly for solid foods to desirable state ready for swallowing. OFSP puree-wheat flour composite bread had significant ($p<0.05$) increase in chewiness at refrigeration temperature as depicted all through due to increases in hardness, springiness and cohesiveness. Resilience decreased with increase in storage temperature. At 30℃, resilience was significantly lost in white bread than in OFSP puree-wheat flour composite bread as shown in Table 4.7.

Table 4.7: Texture Profile Analysis of OFSP and white bread

Samples		OFSP bread				White bread			
Storage Temperature		**7°C**	**20°C**	**25°C**	**30°C**	**7°C**	**20°C**	**25°C**	**30°C**
Hardness (N)	Baseline	1.472 [ab]	1.150[a]	2.169 [bc]	2.771 [cd]	2.152 [bc]	3.424[d]	2.305 [bc]	2.456 [c]
	End line	4.647[e]	2.501 [c]	2.922 [cd]	5.217[ef]	6.023[f]	5.223 [ef]	5.002[e]	5.500 [ef]
Springiness	Baseline	0.9101[abc]	0.8861[ab]	0.9030[abc]	0.9150[abc]	0.9158 [abc]	0.9068 [abc]	0.9150[abc]	0.9855[de]
	End line	0.8919[ab]	0.8655[a]	0.9525 [cd]	0.9051[abc]	0.9051[abc]	0.9216[bc]	0.8911 [ab]	1.0144[e]
Cohesiveness	Baseline	0.7817[d]	0.7894[d]	0.8768[e]	0.7680[cd]	0.7724[cd]	0.7592[cd]	0.8759[e]	0.7615[cd]
	End line	0.6286[a]	0.7550[bcd]	0.9480[ef]	0.7172[bcd]	0.7143[bcd]	0.6907[abc]	0.9545[f]	0.6566[ab]
Gumminess	Baseline	1.490[ab]	0.906[a]	1.668[b]	2.368[cde]	1.641[b]	2.431d[e]	1.750[bc]	1.871[bcd]
	End line	2.915[ef]	1.884[bcd]	2.067[bcd]	2.889[ef]	3.956[gh]	3.743[g]	3.446[fg]	4.443[h]
Chewiness	Baseline	1.058[ab]	0.829[a]	1.220[abcd]	1.152[abc]	1.604[bcde]	2.240[fg]	1.502 [bcd]	1.657[cde]
	End line	2.598[gh]	1.706[cdef]	2.130[efg]	1.774[def]	3.059[hi]	3.798[j]	3.582[ij]	3.270[ij]
Resilience	Baseline	0.3349[def]	0.3559[f]	0.3296[cdef]	0.4321[g]	0.3163[bcdef]	0.3243[bcdef]	0.3494[ef]	0.4958[h]
	End line	0.2739[ab]	0.3006[bcde]	0.2464[a]	0.6796[i]	0.2796[abc]	0.2719[ab]	0.2831[abcd]	0.9193[j]

All values reflect mean counts. Values bearing different letters in each row are significantly different ($p<0.05$)

4.4 Conclusion

Use of OFSP puree in bread baking improved the quality of bread as the puree-wheat flour composite bread exhibited desirable levels for the moisture content, water activity and low microbial growth, hence longer shelf-life compared to the white bread. OFSP bread was also nutritionally beneficial as it contained higher amounts of β-carotene even after storage for 7 days. OFSP puree-wheat flour composite bread had a desirable textural property especially cohesiveness and hence crumbled less. By visual observation, the white bread that was subjected to analysis showed mold growth as from the fourth day while OFSP puree-wheat flour composite bread showed spoilage from the sixth day. The OFSP puree-wheat flour composite bread is hence more shelf-stable. However, the OFSP puree-wheat flour composite bread had less volume than the white bread and hence seemed smaller in size although the bread's weight was similar. Storage at 7℃ is recommended as it preserved the quality of the samples. However, the storage in refrigeration increases the rate of bread staling. This can be reverted by reheating the bread before consumption.

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CHAPTER FIVE

5.0 General Conclusion and Recommendation

5.1 Conclusion

Use of OFSP puree in bread baking influenced consumer knowledge, practices, sensory acceptance and willingness to pay for the OFSP puree-wheat flour composite bread. There was a significant relationship between consumer demographics; age and education attainment, knowledge about the bread and root and acceptance of OFSP puree-wheat flour composite bread as indicated by the positive correlation coefficient. The predominant sensory attributes for consumer's acceptance were softness, color and taste which had the most impact on the acceptability of the product.

Substitution of wheat flour with OFSP puree influenced the quality and shelf-stability of bread. The OFSP puree-wheat flour composite bread is more nutritious than the white bread as it contained β-carotene which was undetected in the white bread. Temperature, however, resulted in thermal deterioration of the β-carotene content in the OFSP puree-wheat flour composite bread. The OFSP puree-wheat flour composite bread had a longer shelf-life than the white bread as it maintained lower water activity throughout shelf-life study period.

5.2 Recommendation

Storage of bread in the refrigerator could preserve the carotenoids in the OFSP puree-wheat flour composite bread. However, storage should not be for long as this would result to deterioration of other attributes especially texture. This study focused on β- carotene content due to storage conditions. However further analysis should be done to determine β-carotene retention in the OFSP puree-wheat flour composite bread after processing.

Functional foods are not only intended to get rid of hunger but to provide consumers with the essential nutrients, promoting both physical and mental well-being by preventing nutrition-related diseases. This study strongly recommends marketing of OFSP puree-wheat flour composite bread based on its nutritional benefits. This should be well indicated during labelling of the bread and hence the need for better packaging. Consumer profile and demographics have been seen to have a relationship on consumer behavior and therefore can be used to predict consumer preferences, hence product promotion.

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Appendices

1. **Plagiarism report**

Turnitin Originality Report

CONSUMER PROFILING AND QUALITY CHARACTERISTICS OF COMMERCIALLY TRADED ORANGE- FLESHED SWEETPOTATO (OFSP) PUREE BREAD IN KENYAby Wanjuu Cecilia Wambui

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2.Consumer profile questionnaire

questionnaire type		coding
Location	Location of store	1. Nairobi 2.Kisumu 3. Kakamega 4.Kiambu 5.Kajiado
Store ID	Name of store	
Gender	Gender of respondent	1. Male 2. Female
Age	Age of respondent	
Region	Where did you spend most of your childhood ?	1. Nairobi 2. Western region 2. Eastern region 3. Central region 4. Rift valley 5. The Coast 6. The North Ea
Education	What is the highest level of education you have attained?	1. Primary 2.Secondary 3.College/University
Employment	What is your current employment status ?	1. Formally employed. 2. Self-employed. 3. Unemployed 4. Student
Income	What is the average monthly income (KES)?	
Household_size	How many members are in your household ?	
Knowledge- OFSP	Have you heard about the OFSP before?	1. Yes 2. No
Knowledge- OFSP bread	Have you heard about the OFSP bread?	1. Yes 2. No
Purchase	Have you bought the OFSP bread before?	1. Yes 2. No
Nutritional knowledge	Are you aware of nutritional benefits derived from OFSP bread?	1. Yes 2. No
Preference	What are some nutritional benefits derived from OFSP bread?	1.Energy 2. Vitamins 3. Minerals 4. Good eye sight 5. Anti-cancer 6. Prevents disease 7.Prevents disability
Children	Do you give OFSP bread to children?	1.Yes 2.No
Eating	How do you eat OFSP bread	1.Breakfast 2. Snack 3. Lunch 4. Dinner
Frequency	How often do you buy the OFSP bread?	1. More than once a week 2. Once a week 3. Twice a month 4. Once a month 5. More than once a month 6. Never
Quantity	How many loaves do you buy at a time?	
Smell_OFSP bread	How do you like the smell of OFSP bread	code ranking
Colour_OFSP bread	How do you like the colour of OFSP bread ?	code ranking
Taste_OFSP bread	How do you like the taste of OFSP bread?	code ranking
Hardness_OFSP bread	How do you like the softness of OFSP bread ?	code ranking
Aftertaste_OFSP taste	How do you like the after-taste of OFSP bread ?	code ranking
Overall_liking_OFSP bread	How would you rate OFSP bread overally	code ranking
Purchase time	What time do you prefer buying the OFSP bread?	1.Early Morning 2. Late morning 3. Afternoon 4.Evening
Knowledge	Do you usually check the expiry date before purchase of OFSP bread?	1. Yes 2. No
Storage	Where do you store your bread?	1. Open 2. Cupboards 3. Refrigerator
Storage duration	How long does the bread remain in storage	1. 1 day 2. 2 days 3. 3 days 4. > 3 days
shelf-life of OFSP	Compared with other breads does the OFSP bread stay longer?	1. Yes 2. No
Willingness to pay	Are you willing to pay the same amount for OFSP bread as white bread?	1. Yes 2. No
	If Yes, ask the following questions	
Willingness to pay+5	If the current price of OFSP bread increased by KSh 5 would you buy it?	1. Yes 2. No
Willingness to pay+15	If the current price of OFSP bread increased by KSh 15 would you buy it?	1. Yes 2. No
Willingness to pay+25	If the current price of OFSP bread increased by KSh 25 would you buy it?	1. Yes 2. No
	If No, ask the following questions	
Willingness to pay-5	If the current price of OFSP bread decreased by KSh 5 would you buy it?	1. Yes 2. No
Willingness to pay-15	If the current price of OFSP bread decreased by KSh 15 would you buy it?	1. Yes 2. No
Willingness to pay-25	If the current price of OFSP bread decreased by KSh 25 would you buy it?	1. Yes 2. No
	preference code ranking	
CODE: Ranking	9. like exteremely 8. like very much 7. like moderately 6. like slightly 5 neither like nor dislike	
	4. dislike slightly 3. dislike moderately 2. dislike very much 1. dislike extremely	