UNIVERSITY OF CAPE COAST

ORANGE FLESHED SWEET POTATO: ITS USE IN COMPLEMENTARY INFANT FORMULA

BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ……………….......... Date: ……………..

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Supervisors' Declaration

We hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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ABSTRACT

A complementary food was developed from the vitamin A rich orange fleshed sweet potation to help reduce vitamin A deficiency among infants. Experimental research design was used for the study. Fifty six infants of ages 6-24 months were purposively sampled, together with their mothers, to evaluate 3 complementary food samples code named GAD, PEA, SAB and a control KAN. A questionnaire was used to collect data. The samples were formulated from orange fleshed sweet potato, anchovies, onion and tomatoes and the nutrients and functional properties determined. The results showed that the 3 complementary foods were nutrient dense with high moisture content highest in PEA and least in GAD. Although GAD had the least moisture content, it turned out to have the highest ash content. GAD, PEA and SAB were all high in protein and fibre but lower in fat and carbohydrate, GAD had the highest β carotene content and bulk density while SAB had the least for both parameters. The water absorption capacity was higher in PEA, giving it a high swelling power but lowest solubility index. The lower absorption capacity of SAB was coupled with highest solubility index. GAD on the other hand had low swelling power. KAN (control) was the most accepted, followed by GAD, PEA and SAB although it was not significantly different from these 3. Comments received from the evaluation by panellists showed that probably, decreasing the amount of fish powder added and making the texture smooth would make all 3 products liked as much as KAN, the control. It is recommended that the complementary food samples be reformulated so as to increase the carbohydrate content.

KEY WORDS

Complementary Foods

Infant

Orange Fleshed sweet potatoes

Sensory Evaluation

Vitamin A

Vitamin A Deficiency

β Carotene

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DEDICATION

To my parents and family

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LIST OF ACRONYMS

AOAC	Association of Official Analytical Chemists
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistic
OFSP	Orange Fleshed Sweet Potatoes
G	Gram
Mg	Milligram
ml	Millilitre
RDAs	Recommended Daily Allowances
RE	Retinol Equivalent
µg	Microgram
µg/dL	Microgram per dicilitre
µg/g	Microgram per gram
UNICEF	United Nations Children’s Fund
VAD	Vitamin A Deficiency
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

Background to the Study

Vitamin A deficiency (VAD) is a global public health problem and is significant in under-privileged communities of the world (World Health Organization, 2009). Asia, Latin America and Africa record the highest incidence of vitamin A deficiency (World Health Organization, 2006). Sommer and Davidson (2002) defined vitamin A deficiency as serum retinol less than 20 microgram per decilitre (ug/dL). Food and Agriculture Organization (FAO) in 2009 projected that about 1.02 billion people globally will be affected by acute micronutrient deficiencies with vitamin A deficiency being ranked as the highest (Nair, Arya, Vidnapathiranad, Tripathi, Talukder & Srivastava, 2012). African countries report the greatest number of pre-school children with night blindness and for more than one-quarter of all children with sub clinical vitamin A deficiency (WHO, 2009). According to West (2002), about 127.2 million pre-school children worldwide were deficient in vitamin A. Out of this 25% were found in developing countries like Ghana and 26% lived in Africa. Egbi (2012) reported an estimated vitamin A deficiency prevalence rate of 35.6% in Ghana.

Vitamin A is an essential nutrient needed in minute amounts for the normal functioning of the visual system, boosting of the immune system, maintaining epithelial cellular integrity and also supporting growth and development (Tariku, Fekadu, Ferede, Abebe & Adane, 2016). It is found in a number of forms such as retinol, retinal, retinoic acid or retinyl ester. Vitamin A requirements are usually expressed in retinol equivalents (RE). Vitamin A deficiency (VAD) arises when a diet provides inadequate vitamin A to meet physiological needs which may be worsened by high rates of infection, especially diarrhoea and measles (WHO, 2009). Vitamin A deficiency causes night blindness, severe anaemia, wasting, reproductive and infectious morbidity, and increase risk of mortality (Sommer & Davidson, 2002). VAD also increases the severity of infections such as measles and diarrhoeal disease in children, and slows recovery from illness (GSS, 2008). Acute vitamin A deficiency (VAD) causes xerophthalmia, which is the inability to see in low light or darkness (Ross, 2010).

Infants commence their life with an urgent need for vitamin A. Hence, infants from 1–59 months of age have increased need of vitamin A to sustain their rapid growth and to fight infections (WHO, 2011). United Nations Children's Fund (UNICEF) (2016) reports that high dose of vitamin A supplements ought to be provided to infants every four (4) to six (6) months until they are five years old.

Vitamin A can be found in two (2) main dietary sources; retinoid from animal sources and pro-vitamin A carotenoid from plants. Retinoid is found in animals and its products like fish, eggs, liver and full -cream milk (Guthrie & Picciano, 1995; Trumbo, Yates, Schlicker & Poos, 2001), whereas pro-vitamin A carotenoid is found in plant based foods such as dark green, orange and yellow fleshed vegetables and fruits (Harrison, 2005), which is later converted into retinol (vitamin A) in the gut (de Pee, West, Hautvast, Muhilal, Karyadi & West, 1995). Foods from animal origin provide the best source of vitamin

A. However, a greater number of people in developing countries like Ghana cannot afford purchasing and consuming lots of animal products (Onyango, 2003).

After the first 6 months of an infant's life, breast milk alone cannot provide the full nutrients needed for proper growth and development thereby creating a gap in the nutritional requirements (WHO, 2003; Dewey, 2001), hence the introduction to complementary foods. Nutritional requirements of infants are most critical during this period of complementary feeding where both macro and micronutrients may be insufficient to maintain growth and development (Ojinnaka, Ebinyasi, Ihemeje & Okorie, 2013).

In Ghana, most of the complementary foods prepared are cereal-based (Amagloh, Weber, Brough, Hardacre, Mutukumira & Coad, 2012a). These cereal-based foods are often poor nutritional sources of vitamin A (Amagloh, Hardacre, Mutukumira, Weber, Brough, & Coad, 2012; Amagloh & Coad, 2014). Lutter, Rodriguez, Fuenmayor, Avila, Sempertegui and Escobar (2008) and Amagloh *et al.* (2012), identified vitamin A deficiency to be among the world's most prevalent nutritional problems. There are numerous strategies that can be employed to redress the issues of vitamin A deficiency. These include; food fortification, vitamin A capsule supplementation, food diversification and nutrition education. According to Allen (2008), food–based strategies have been recognized as a more workable and sustainable alternative for addressing micronutrient deficiencies.

Sweet potato is known scientifically as *Ipomoea batatas* [L.] *Lam.* It is one of the chief staple crops and the most key food security promoting root crop in the world, especially in sub Saharan Africa (Low, Lynam, Lemaga, Crissman, Bakr & Thiele, 2009). Sweet potatoes have several health benefits, such as improving blood sugar regulation, improving vitamin A status and reducing risk of several types of cancer (United Nations Population Division, 2007).

According to Picha and Padda, (2009), and Burri, Chang and Neidlinger, (2011), some varieties of sweet potatoes have high amount of ß-carotene, which is a precursor of vitamin A. Orange-fleshed sweet potato is ranked as one of the most competent plant sources of β-carotene, the pro-vitamin A (Hagenimana & Low, 2000) therefore may be used to lessen vitamin A deficiency amongst children. Orange-fleshed sweet potato was chosen in this study because of its high ß-carotene content, which makes it a potential crop in alleviating vitamin A deficiency among children in Ghana.

Statement of the Problem

The period of complementary feeding is a crucial stage in an infant's life. In Ghana, complementary foods are normally prepared from either cereals only or blended with legumes. These complementary foods are not fortified with vitamins and minerals and normally of low nutritive value which affects the developmental growth of infants.

Sweet potato (orange fleshed variety) is grown and promoted in Ghana by the Ministry of Food and Agriculture but is currently being underutilized. It has high β carotene content but easily perishable, therefore it cannot be stored for a long period of time. It should be processed to prolong its shelf life and diversify its uses. Increasing the utilization and the consumption of orange fleshed sweet potato (OFSP) in children's diet may be an excellent approach to reducing vitamin A deficiency in Ghana as an estimated prevalence rate of 35.6% was reported in Ghana in 2012 (Egbi, 2012).

It is in view of this, that the researcher developed complementary food from orange fleshed sweet potatoes that would be accepted by the populace so as to help reduce the problem of vitamin A deficiency especially among infants in Cape Coast and its environs.

Purpose of the Study

The main purpose of the study was to formulate a complementary food from orange fleshed sweet potato. Objectives of the study were to:

1. develop a complementary food,
2. identify the chemical constituents of the complementary food,
3. determine the functional characteristics of the complementary food.
4. Sensorily evaluate the acceptability of the complementary food in terms of: appearance, taste, texture, aroma, and overall acceptability.

Hypotheses

1. H_0: There is no significant difference between the developed complementary food (SAB) from OFSP flour and commercially manufactured (KAN) sweet potato baby food in terms of sensory qualities.
2. H_0: There is no significant difference between the developed complementary food (PEA) from OFSP flour and commercially manufactured (KAN) sweet potato baby food in terms of sensory qualities.
3. H_0: There is no significant difference between the developed complementary food (GAD) from OFSP flour and commercially

manufactured (KAN) sweet potato baby food in terms of sensory qualities.

Significance of the Study

With the persistent vitamin A deficiency in Ghana, coupled with rising cost of vaccines, it will be pertinent to identify alternative sources of vitamin A which are more cost effective and available to all children. Orange fleshed sweet potato (OFSP) is locally grown but underutilized. Developing complementary food from orange fleshed sweet potato (OFSP) would result in numerous benefits to the society and country as a whole. This would lead to increased utilization of orange fleshed sweet potato (OFSP). Again; it would lead to the production of more orange fleshed sweet potato (OFSP) by farmers, which would ensure its affordability on the market. This would also increase the earnings of the families engaged in the production. Above all, it would also add another variety to the already known complementary foods. The results obtained from the study would enhance the understanding and knowledge about orange fleshed sweet potato (OFSP) complementary foods. It would also add to the existing knowledge given by other researchers, related to complementary food; above all it would help reduce the menace of vitamin A deficiency, and its related death particularly among infants and young children in Ghana.

Delimitations

Even though there are other formulated complementary foods, the study was focused on the formulation of complementary food from orange fleshed sweet potato and it was also be confined to infants from six (6) to twenty four (24) months in the University of Cape Coast Hospital in the

Central Region of Ghana. Most especially, this Study would be a hospital-based study conducted among infants aged 6 -24 months who attend child welfare clinic.

Limitations

Due to the changes in the weather, the drying of the samples was changed from sun drying to oven drying. The babies used for the sensory evaluation could not express themselves or talk, so the responses obtained using facial expressions may not fully be representative of what they may be trying to communicate.

Organisation of the Study

This report is organised in five chapters. Chapter one consists of the background of the Study, problem statemen, objectives and scope of the Study. Chapter two looked at the review of related literature on orange fleshed sweet potatoes. Chapter three gives a description of the methods, materials, tools, procedures used in gathering information and analysing the results. Chapter four focused on presentation of results in the forms of tables, charts and its discussion. Chapter five focused on conclusions and recommendations of the Study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter presents literature relevant to the Study. It begins with a review of the origin and distribution of sweet potato, agronomic characteristics and cultivation of sweet potatoes, post-harvest storage of sweet potatoes, economic importance, and utilization of sweet potatoes, nutritional value of sweet potatoes and proximate composition of sweet potatoes. It also reviews origin and distribution of tomato, nutritional and health benefits of tomatoes, origin and distribution of onion, nutritional and health benefits of onion, origin and distribution of anchovies, nutritional and health benefits of anchovies, effects of dehydration, functional characteristics of sweet potato flour, and complementary foods from sweet potato and sensory evaluation of food products.

Origin and Geographical Distribution of Sweet Potato

Sweet potato (*Ipomoea batatas*) is believed to have originated from Central America (Geleta, 2009). According to Austin and Gregory (1988), the plant had most likely been spread by local people to the Caribbean and South America by 2500 BC. Sweet potatoes were introduced to Africa by Spain and Portugal explorers during the 16th century (Zhang, Guo & Peng, 2004). Low, Lynam, Lemaga, Crissman, Barker, Thiele, Namanda, Wheatley and Andrade (2009) also believed that sweet potatoes may have extended from the Americas via slave traders into tropical Africa.

Sweet potatoes are now cultivated in tropical and warm temperate regions, wherever there is sufficient water to support their growth (FAO, 2000). Today, sweet potato is cultivated in most parts of tropical regions including Ghana (Walker, Thiele, Suarez & Crissman, 2011). Sweet potato plant is a branching, creeping vine with spirally arranged lobed, heart shaped leaves and white or lavender flowers. According to FAOSTAT (2012), between the year 2006 and 2010, China produced the largest amount (80%) of sweet potato in the world supply followed by Indonesia, Vietnam, India, Japan and Philippines. In Africa, 11.6million tones of sweet potatoes are produced annually. Uganda is the largest grower of sweet potatoes followed, by Nigeria and Tanzania.

Agronomic Characteristics and Cultivation of Sweet Potato

Sweet potato is known scientifically as *Ipomoea batatas* [L.] *Lam.* It is a perennial tuber crop and a member of the *Convolulaceae* family. There are about 400 species of *Ipomoea*, but only *Ipomoea batatas* has roots that are fit for human consumption (Torres, 1989). Sweet potatoes are grown between 40°N to 32° S of the equator and on the equator it is grown from the sea level to 3000 meters.

Sweet potato is a perennial plant, but is normally grown as an annual crop and is propagated asexually from vine cuttings, or sexually from seed (Woolfe, 1992). The quantity of nutrients contained in sweet potato variety varies from place to place depending on the climate, soil type, the crop variety and other factors (Ingabire & Hilda, 2011). Sweet potato is most commonly grown on mounds or ridges, and occasionally on raised beds, or on the flat (Low *et al.*, 2009). The leaves are simple and spirally arranged alternately on the stem in a pattern known as 2/5 phyllotaxis. Each sweet potato plant produces about 60 – 300 leaves (Somda, Mohammed & Kays, 1991), it also produces flowers of different colours such as white, cream, yellow, orange and purple (Wolfe, 1992; Bovell-Benjamin, 2007).

According to Nair and Nair (1995) certain conditions and practices increase the number of leaves each plant produces. Some of these conditions and practices are; increase in irrigation, decreases in plant density, and nitrogen application. According to Ishiguro, Toyama, Islam, Yoshimoto, Kumagai, Kai and Yamakawa (2004), sweet potato is more tolerant to diseases, pests and high moisture than many other leafy vegetables grown in the tropics. Sweet potato has the ability to stand low soil fertility and climatic conditions and yet give reasonable yield (van den Berg & Laurie, 2004). When compared with other roots and tubers it has a short production cycle, which is 3-8 months from planting (Woolfe, 1992). The edible root tuber is long and tapered, with a smooth skin whose colour ranges from red, purple, brown and beige. Its flesh colour ranges from white through yellow, orange and purple (Villareal, 1982; Dapaah, Asafu-Agyei, Baafi, Adofo, Evelyn & Obeng, 2005)

Sweet potato Varieties

Sweet potato tubers are classified by the colour of their flesh.The flesh of the tuber can be white, cream, yellow, orange, or purple but white and cream are the most commonly grown and eaten in Ghana. According to Hagenimana, Oyunga, Low, Njoroge, Gichuki, and Kabira, 2001; Ofori, Oduro, Ellis, and Dapaah, 2009; Ssebuliba, Nsubuga and Muyonga (2001), sweet potato variety may contain high level of ß-carotene. The colour of the flesh can be used to classify the varieties. Simonne, Kays, Koehler and

Eitenmiller, (1993) also report that on dry weight basis the varieties of sweet potato can be grouped based on their ß-carotene content. The groupings are: non-detectable (<1 µg/g), low ß-carotene (1-39µg/g)–pale orange, moderate ß-carotene (40-129 µg/g) –orange and high ß-carotene (>130 µg/g) – dark orange.

Between 1998 and 2005, the Crops Research Institute (Council for Scientific and Industrial Research (CSIR), in Ghana, released eight varieties of sweet potatoes (Akoroda, 2009). Subsequently, four varieties namely *Faara, Sauti Okumkom* and *SantomPona* were also released (CSIR, 2006; Otoo, Missah and Carson, 2001). In 2005, CSIR-CRI released High –Starch, *Apomuden, Ogyefo* and *Otoo* varieties of sweet potatoes (CSIR-CRI, 2005).

The Apomuden variety has orange flesh tuber therefore named orange fleshed sweet potato (OFSP). It contains more β -carotene than the other varieties. OFSP is known to have an excellent amount of β -carotene which is highly bio available and converted into vitamin A (retinol) in the human body (Haskell, Jamil, Hassan, Peerson, Hossain, Fuchs & Brown, 2004; Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard & Benade, (2005). Sweet potato roots are rich in starch, sugar, vitamin C, β-carotene, iron, and several other minerals (Laurie *et al.,* 2012; Oloo *et al.,* 2014).

The Apomuden variety is an orange-fleshed variety of sweet potato which has more ß-carotene compared with the other varieties, therefore incorporating it into a complementary food for infants between the ages of 6 months and 2 years will be a good alternative which will help reduce vitamin A deficiency.

Sweet Potato Production in Ghana

Ghana is located on West Africa's Gulf of Guinea; it is a few degrees north of the Equator. The country covers a total area of 238,538 square kilometres (World Atlas, 2017). Root and tuber crops such as sweet potatoes contribute greatly to Ghana's agricultural growth. Ghana is one of the West African countries whose Gross Domestic Product (GDP) is driven principally by agriculture (Dittoh, Bhattarai & Atosiba, 2013; Wayo, 2002).

According to CSIR – CRI, approximately 40% of GDP is contributed by roots and tubers whilst cereals account for 7% (CORAF/IFPRI, 2006). Sweet potato ranks fourth in Ghana after cassava, yam and cocoyam (Ennin, Dapaah & Asafu-Agyei, 2007). Sweet potato is grown in all the regions except Western region. Upper East region is the main producer which contributes 34.9% of what is produced in Ghana, followed by Eastern region with 26.4% and Upper West with 14.8%. Greater Accra and Ashanti regions are the least producing regions (MoFA & SRID, 2012). Table 1 presents the various regions with the amount of sweet potato produced in the year 2012.

Table 1: Sweet potato production in Ghana

Region	Area	Percentage %	Production	Percentage %
Central	371	3.90	6,490	4.90
Volta	880	9.10	15,340	11.60
Eastern	1,030	10.70	34,910	26.40
Grater Accra	38	0.40	640	0.50
Ashanti	37	0.40	620	0.50
Brong Ahafo	145	1.50	2,390	1.80
Northern	414	4.30	6,070	4.60
Upper East	5,550	57.70	4600	34.90
Upper West	1,1570	12.0	19,530	14.80
Total	9,622	100	131,990	100

Source: MoFA & SRID, (2012)

About ninety thousand (90,000) tonnes of sweet potatoes are produced annually in the tropical regions of Ghana (FAOSTAT, 2006). Although, sweet potato is grown in almost all the regions, it is still not very well inculcated into the diet of the average Ghanaian (Adu-Kwarteng, Otoo and Oduro, 2001). This is because sweet potato is often considered a low-grade crop that is consumed by the poor, thus, not being given the essential thought it deserves as a staple food crop (Walker, Thiele, Suarez & Crissman, 2011).

. In Ghana, sweet potato is principally significant in the Northern and Coastal belts where it is both food and cash crop (Otoo, Missah, Osei, Manu-Aduening, Carson, Oduro *et al*., 2000; Otoo, Missah & Carson 2001; MOFA-SRID, 2012). It is produced mostly by subsistence farmers on small scale without inputs such as fertilizer. In the Cape Coast Metropolis, communities that cultivate sweet potato are Moree, Jukwa, Efutu, Ankaful and Koforidua (Teye, 2010).

Post-harvest Storage of Sweet Potatoes

Post-harvest storage of sweet potato is a major problem because the tuber is bulky and after harvesting it has a short shelf life. Most crops suffer the improper post-harvest treatment such as chilling injury, poor handling and extreme temperatures. On harvest, sweet potato roots are stored mainly in rooms (in sacks) and in pits (Engoru, Mugisha & Bashasha, 2005, Nagujja & Yanggen, 2005).

Research works conducted in Ghana by Osei-Gyamera (2000), Duku (2005) and Golokumah (2007) on different traditional storage techniques gave average shelf-life of 2 weeks. Birago (2005) and Golokumah (2007), also conducted studies and found that, sweet potato farmers in the Cape Coast

Metropolis do not store up their harvested sweet potato due to the high deterioration in storage and improper storage technology. Farmers therefore, practice in-situ storage or piece meal harvesting (Teye, 2010).

By tradition, harvested tubers are stored in baskets covered with banana leaves. Tubers can also be stored in dug pits lined with a layer of dried grass followed by another layer and at least 5 cm of top soil. According to Engoru, Mugisha and Bashasha (2005) the pit is reported to be effective for at least 4 months but its use is constrained by rodents and rotting

According to Amoah, Teye, Abano and Tetteh (2011), traditional barns and other forms of storage structures used widely in tropical countries to protect the integrity of the tuber have not yielded the desired results. Department of Agriculture, Forestry and Fisheries (DAFF), (2011) revealed that storage temperature is between 12 and 15 °C. Relative humidity should be maintained between 75 to 80 % to avert extreme water loss from the roots. Some aeration should be provided to avoid carbon dioxide build up.

Economic Importance of Sweet Potato

Economically, sweet potato plays a vital role in improving the standard of living of people across the globe. Sweet potato is ranked as the seventh most important food crop in the world after rice, wheat, irish potatoes, maize, yam and cassava (Loebenstein, 2009). Sweet potato is an important versatile crop in many parts of the world.

In the developing world, sweet potato plays a significant role in the global food structure, where they are ranked among the top 10 food crops (Phillips, Taylor, Sanni & Akoroda, 2004). In terms of global production, sweet potato is ranked as the seventh most important food crop (Loebenstein, 2009). About 133 million tonnes of sweet potatoes is produced annually worldwide (Warammboi, Dennien, Gidley & Sopade, 2011). Out of this amount, China produces about 85.2 million tonnes of it.

In Sub-Saharan Africa, sweet potato is one of the most widely grown root crops (Low *et al.*, 2009). In Ghana, 73,400 hectar of sweet potato are planted per annum, and in order of importance it comes after cassava and yam (FAOSTAT, 2010). Sweet potato is a root crop that provides food to a great section of the world population, especially in the tropics where the bulk of the crop is grown and eaten as food (Opeke, 2006).

According to Consultative Group on International Agricultural Research [CGIAR] (2000), in Asia over 50% of sweet potato produced is used to feed farm animals whereas in Africa it is for human consumption. Sweet potato has numerous industrial applications (Lin, Lai, Chang, Chen & Hwang, 2007). In Nigeria, orange-fleshed sweet potato is processed into flour and sold at higher prices than flour from other varieties (Akoroda, Edebiri, Egeonu, Bello & Yahaya, 2007; Odebode, 2010). Amante (1995) reports that in the ice cream manufacturing industries sweet potato flour is used as a stabilizer. Local drinks like Kunu-zaki and burukutu are sweetened with sweet potato flour and for fortifying baby foods (Tewe, Ojeniyi & Abu, 2003).

In Uganda, sweet potato roots are processed into dried chips which are eaten during periods of food shortage (Kapinga & Carey, 2003). Sweet potato can also be processed into flour and used for food items such as bread, starch for noodles and as raw material for industrial starch and alcohol. According to Rahman, Wheatley, and Rakshit (2003), the starch produced is of a higher rank which is appropriate to be eaten as food and pharmaceutical uses.The starch can also be used as a thickener, water binder, emulsion stabilizer, and gelling agent (Iheagwara (2013); Eleazu and Ironua (2015). It is also used in textile, paper, cosmetics, insulating and adhesive industries. Sweet potato flour is also used for making a variety of food products such as pastries (cakes, cookies, biscuits); doughnuts, breakfast foods (instant porridge, crisp, flake-type products); farinaceous goods; cold sauces (soy sauce, ketchup); and brewing adjuncts (van Hal, 2000; Mais & Brennan, 2008).

Sweet potato is processed into chips in the same way as french fries from Irish potato (Brigato, Oliveira & Collares-Quieroz, 2010; Hagenimana & Omo, 2010). Sweet potato has prospective carbohydrate base in baby food manufacturing (Nandutu & Howell, 2009). It also has great potential for bio fuel production (Mays, Buchanan, Bradford & Giordano, 1990).

Utilization of Sweet Potato

Sweet potato is grown for human consumption in more than 100 countries, but mostly considered as a substitute food and not a staple food because it is underutilised. According to Chittaranjan (2007) in the United States of America, orange fleshed potatoes are used as a source of natural dye or valued as a healthy food due to their high β-carotene content. The starch produced from sweet potatoes is graded as high –grade one which is suitable for food and in the pharmaceutical industries. In Indonesia, food items such as tomato sauce, tomato ketchup, dried-cake, spongy cake, and biscuit are produced from sweet potato which is used as a major ingredient (Suismono, Indrasari & Damardjati, 1994).

In Asia and some parts of Africa, the leaves are served as vegetables (Ofori *et al*., 2009). According to Consultative Group on International

Agricultural Research (CGIAR) (2000), about 50% of sweet potatoes grown in Asia is used to feed farm animals. Lopez, Iguaz, Esnoz and Virsed (2000) established that sweet potato can be used in manufacturing of sweet potato flakes which is also called sweet potato buds. According to Truong and Fermentira (1990), sweet potato can also be used in the preparation of beverage. Ellong, Billard and Adenet (2014) also report that sweet potato can be used in the production of beverages such as wine, liquor as well as vinegar, sugar, biscuits, flour and pasta.

In Uganda, sweet potato produced into flour, is used for the preparation of buns, chapattis and mandazi (Hagenimana & Owori, 1997). Also, in Nigeria sweet potato is consumed boiled, roasted or sliced and fried as chips. At times, the tubers are used in the preparation of flour, which is used in the sweetening of porridge. It is also used in the preparation of pounded foofoo (Agbo and Ene, 1994).

In Ghana sweet potatoes have many cookery uses. The tubers are mostly deep fried and eaten as snack or boiled and consumed as “ampesi” with stew. According to Missah, Kissiedu and Okoli (1993) sweet potato is also used in the preparation of “oto” (a traditional Ghanaian dish for Akans made from boiled and mashed tubers with pepper, onions, and tomatoes). It is also used as a sweetener in a local snack called“bodoo” (oral conservation).

A research by Ellis, Oduro, Fianko and Otoo (2001), found that sweet potato varieties like “Santom Pona” and Hi-Starch grown in Ghana can be used in the preparation of gari (grated and fried). Sweet potato variety “okumkom” has been found to posses’ relatively high water binding capacity which is an essential condition for the manufacturing of all types of bakery products (Oduro, Ellis, Nyarko, Koomson & Otoo, 2003).

Nutrient and health benefits of Sweet Potato

Sweet potato is ranked highest in nutritive value, outranking most carbohydrate foods in vitamins, minerals, protein and energy content (Onuh, Akpapunam & Iwe, 2004). According to U.S. Department of Agriculture (USDA) (2009), 100 grams of uncooked sweet potato contain the following amount of nutrients. Table 2 presents the nutrients that can be obtained from 100g of raw sweet potatoes.

Table 2: Nutritional Value of Raw Orange Fleshed Sweet Potato per 100 g

Nutrients	Unit	Value per 100g
Water	G	77.28
Energy	Kcal	86
Protein	G	1.57
Total lipid	G	0.05
Ash	G	0.99
Carbohydrate	G	20.12
Fiber, total dietary	G	3.00
Calcium	G	30.00
Iron	Mg	0.61
Magnesium	Mg	25.00
Phosphorous	Mg	47.00
Potassium	Mg	337.00
Sodium	Mg	55
Vitamin C	Mg	2.40
Pantothenic acid	Mg	0.80
Vitamin B-6	Mg	0.209
Vitamin A	IU	14187

Source: USDA (2009).

Sweet potato roots and tops hold a range of chemical compounds appropriate for human health (Woolfe, 1992). According to Ofori *et al*. (2005) sweet potato is about 50% more nutritious than Irish potato. The major nutrients in sweet potato are carbohydrates in the form of starch and simple sugars, protein, fat and fat soluble vitamins. Moreover, varieties with yellow and the orange fleshed contain considerable amounts of β carotenes (Allen, Corbitt, Maloney, Butt & Truong, 2012). β carotene is essential for growth, good eye sight and for boosting the immune system. Table 3 summarises the nutrients obtained from 100g of orange-fleshed and white-fleshed sweet potatoes.

Table 3: Nutrients that can be obtained from consumption of 100g of OFSP

	Nutrient						
Variety	Energy (kCal)	Protein (g)	Fiber (g)	Iron mg)	Zinc (mg)	Vitamin A (mcg (RAE)	Vitamin C (mg)
OFSP	76	1.37	2.5	0.72	0.2	588	12.8
WFSP	76	1.37	2.5	0.72	0.2	0.05	12.8

Source: Helen Keller International (2012)

RAE; Retinol Activity Equivalent: 1 RAE =1mcg retinol = 12 mcg β-carotene.

OFSP (orange fleshed sweet potato), WFSP (white fleshed sweet potato).

From the table, the amount of vitamin A obtained from OFSP is 588 mcg which is higher than that obtained from WFSP which was 0.05 mcg. Sweet potatoes also contain a good amount of minerals such as calcium and potassium (Luis, Rubio, Gutiérrez, González-Weller, Revert & Hardisson, 2013), carbohydrates, fiber, antioxidants, starch and vitamins such as vitamin A & C (Anderson & Gugerty, 2013; Odongo, Mwanga, Owori, Niringiye, Opio, Ewell, Berga, Agwaro, Sunjogi, Abidin, Kikafunda & Mayanja, 2002).

Fibre provides a feeling of satiety which helps in controlling the ingestion of food and promotes a healthy digestive tract; it also keeps the bowels healthy and lowers cholesterol. Vitamin C helps fight infections, heal wounds and aids in the absorption of iron. Although sweet potatoes are rich in carbohydrate, its glycemic index is low. This slows the rate of digestion of complex carbohydrate, lowers the rate of assimilation of sugars into the blood stream. This makes it excellent for diabetics and obsessed people (Ellong *et al*., 2014; Fetuga, Tomlins, Henshaw & Idowu 2014; International Life Sciences Institute 2008; Ooi & Loke, 2013). According to Willcox *et al*. (2009) the danger of constipation, diverticulosis, colon and rectal cancer and obesity can be lowered by the eating of sweet potato.

According to Oloo, Shitandi, Mahungu, Malinga and Ogata (2014), the protein found in sweet potatoes is higher than that found in roots and tubers such as cassava and yam. It is ranked to be high biological value due to its high lysine content; the protein content ranges from 1% to 2%, however the lipids content is low ranging from 0.1 to 0.4 % (Mazzei, Puchulu and Rochaix, 1995; Food and Agriculture Organization [FAO], 2002). The leaves of sweet potatoes are rich in essential amino acids, such as lysine and tryptophan which is always inadequate in cereals (Mwanri, Kogi-Makau & Laswai, 2011; Oloo, Shitandi, Mahungu, Malinga & Ogata, 2014). A study has shown that sweet potato leaves contain as much vitamins, minerals and other nutrients as contained in spinach (Ishiguro, Toyama, Islam, Yoshimoto, Kumagai, Kai &

Yamakawa, 2004). Orange fleshed sweet potato is a good source of dietary fibre, minerals, vitamins and antioxidants such as phenolic acids, anthocyanins, and tocopherol. They also provide vitamin C, B vitamins (B2, B3, & B6), potassium and copper (FAO, 2007, Kosambo, 2004; Welch, 2005 & WHO, 2002).

Two research work conducted by Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard, Spinnler and Benade (2005) & Low, Arimond, Osman, Cunguara, Zano and Tschirely (2007) in South Africa and Mozambique respectively revealed and proved that consuming orange fleshed sweet potato on regular basis potentially increase the vitamin A status in children. Hagenimana, Low, Anyango, Kurz, Gichuki and Kabira (2001), also reported that in Kenya women and children had their vitamin A intake boosted through the consumption of orange fleshed sweet potatoes (OFSP).

Having enumerated these health benefits of sweet potato, promoting its utilization will help improve the health status of infants who are fed with it. The β-carotene of sweet potatoes may help reduce VAD in Ghana and Africa. Therefore incorporating orange fleshed sweet potato into a complementary food will enhance the nutritional value of complementary foods.

Proximate Composition of sweet potato

According to Maleki (2003), sweet potato can be considered as an alternative food item because it may have benefits as infant food above other cereal based baby foods, particularly wheat and wheat related cereals, owing to its hypoallergenic effect.

Avula (2005) reports irish potato to be higher in protein (9.1± 0.1) than sweet potato of (6.6±0.1), the fat content in sweet potato was 1.0±0.07

compared to irish potato which recorded a value of 0.3±0.02. Total carbohydrates in potato were 75.3 ±1.0 against sweet potato which was 73.0±0.6. Dery (2012) reiterates that, fresh tuber moisture content ranged from 56.30%±1.96 to 84.90%±1.71. Orange fleshed sweet potato variety "Apomuden" recorded the highest moisture content of 84.90±1.71. Laryea (2016), reports of lower carbohydrate content 83.29% as compared to what was reported by Dansby and Bovell-Benjamin (2003) which was 90.6%. Again Laryea (2016) reports of a higher protein content of 5.17% whiles Dansby and Bovell-Benjamin (2003) report protein content of 1% for another orange-fleshed variety.

Senanayake, Ranaweera, Gunaratne and Bamunuarachchi (2013) studied five varieties of sweet potatoes and found the protein content to range between 1.2 and 3.3% on dry weight basis. Truong, McFeeters, Thompson, Dean and Shofran (2007); Steed and Truong, 2008;Yencho, Pecota, Schultheis, VanEsbroeck, Holmes, Little, Thornton and Truong (2008) researched on the ß-carotene content of Beauregard and Covington which are varieties of orange fleshed sweet potato; Beauregard contained 9.4 per mg/100g while Covington had 9.1mg/100g. Olatunde *et al.* (2015) found moisture content in sweet potato flour as 8.06–12.86%, protein 0.55–5.87%, fat 0.04–1.45%, fiber 0.08–5.54%, ash 0.15–2.09% and carbohydrate 74.55–90.92%. The moisture content of sweet potato flour was within the range of 2.50–13.2% as stated by Van, (2000); Osundahunsi *et al*. (2003) and Aina *et al*. (2009). According to Ogunlakin *et al.* (2012), protein levels in sweet potato flour ranged between 4.93-5.17%, fat was between 0.50-0.57% and ash between 2.47-2.87%, oven dried flour had the highest values in each case.

Rodrigues *et al*. (2016) report moisture content of 6.9 to 10.97% in flours however OFSP flours showed higher protein content 4.8% while the flour showed 0.39% fat and 90.13% of carbohydrate.

Looking at the proximate composition of sweet potato it can be seen that it is nutritious. Literature proves that sweet potato has short maturity cycle and is grown in communities around Cape Coast Metropolis such as Moree, Jukwa, Efutu, Ankaful and Koforidua therefore most people can easily acquire and use it.

Origin and Distribution of Tomato

Tomatoes (***Solanum lycopersicum***) belong to the night shade family. It originated from the South America specifically in Peru, Bolivia, and Ecuador (Orzolek, Bogash, Harsh, Kime & Harper, 2006). Tomato is one of the most commonly grown vegetables in the globe (Srinivasan, 2010). According to Alam, Tanweer and Goyal (2007), tomato is classified as a vegetable and can be consumed in various ways, including raw, as an ingredient in many dishes and sauces and in drinks.

Nutritional and Health Benefits of Tomato

Tomatoes have a lot of health benefits. Tomatoes also provide a good quantity of vitamin A and C but they are also a good source of minerals such as phosphorus and potassium. Folate and high levels of the antioxidants, β-carotene and lycopene can also be obtained in the consumption of tomatoes.

One medium sized tomato has 552 mcg of β carotene and 3,165mcg of lycopene which can help boost the immune system by fighting the damaging effects of substances called free radicals (Mann, 2010). According to Sun, Simonand and Tanumihardjo (2009), antioxidants assist to protect us from diseases such as cancer and slow the aging process. These include lowering hypertension, urinary tract infections, skin ailments, diabetes, and good for gut health and eyesight. It contains numerous antioxidants which combat various types of cancer. This means that the consumption of foods prepared with tomatoes has the potential of boosting the immune system and also reducing the prevalence rate of cancers, urinary tract infections, skin ailments, diabetes, and promote good eyesight in infants as it also contains high levels of the antioxidants, β-carotene.

Proximate Composition of Tomato

Opadotun, Adekeye, Ojukwu and Adewumi (2016) conducted a comparative nutritional analysis on tomatoes using two different drying methods: sun drying and oven drying. The mean value of the moisture content for samples A (control), B (sundried) and C (oven dried) were 40.14±0.01, 9.04±0.03 and 8.67±0.01 % respectively. The ash content of samples A, B and C recorded a mean value 20.19±0.00, 42.75±0.01 and 49.36±0.00 % respectively. The lipids content had a mean value of 1.77±0.01, 1.27±0.01 and 1.19±0.01 % for samples A, B and C respectively. The mean results of protein were 28.97±0.00, 15.81±0.01 and 13.25±0.01% for A, B and C respectively. The mean values for fibre were 0.19±0.01, 0.21±0.01 and 0.28±0.00 % for sample A, B and C respectively. The mean of the carbohydrates content were 8.75±0.02, 30.93±0.04 and 27.27±0.01 % for A, B and C respectively. The results of these investigations showed that the tomatoes dried under a controlled environment can be preserved longer than sun dried sample due to lower moisture content. This will inhibit microbial activities which destroy stored food products. The sundried sample (B) slightly retained some nutritional constituents (lipids, crude proteins and carbohydrates) than oven dried sample (C).

An experiment was conducted on a sandy loam soil to evaluate the growth, fruit yield and quality of seven varieties of tomato. The results showed that protein content ranged from 0.007 to 42.55%, fat 3.51 to 4.22 % and fibre 6.07 to 7.42 %. All the seven tomato varieties are good sources of quality and mineral elements. Although, there is inconsistence in the results of the nutritional compositions of tomato fruits, and the local varieties recorded most of the nutritional values more than the other varieties. The variation in the nutritive values of different varieties of tomato used in this study might be due to the environmental effect in which they are grown (Olaniyi, Akanbi, Adejumo & Akande, 2010). Tomato is as an essential and major ingredient in cooking most Ghanaian dishes (Tambo & Gbemu, 2010) hence most people especially mothers resort to its use.

Origin and Distribution of Onion

Onion (*Allium cepa* (L)) is one of the species of a large genus (*Allium*) family, which is safe for human consumption. It has more than 700 species (Burnie, Forrester, Greig, Guest, Harmony, Hobley *et al.*, 1999). It is believed to have originated in the region comprising Afghanistan, Iran, and the southern portion of the former Soviet Union (Havey, 1995)

Onions (*Allium cepa* L.) are usually part of the every day diet for most people and a crop of enormous economic importance all over the world (Mogren, Olssen & Gertsson, 2007). It is used in almost all food preparation (Hossain & Islam, 1994). According to Yalcin and Kavuncuoglu (2014), onion seeds are also eaten, but their commercial availability is currently limited.

Onions can be used in diverse ways such as fresh, powdered, dehydrated, oil, juice, salt or pickled. The unique flavour of onion is used to improve recipes and other flavours used.

Nutritional and Health Benefits of Onion

Consuming onion brings a lot of health benefits due to its nutritional value. According to Obeng-Ofori, Danquah and Ofosu-Anim (2007), a 100g edible portion contains energy, 31 cal; protein, 1.5g fat, 0.6g; total sugar, 7.2g; other carbohydrates, 0.3g; vitamin A, nil; thiamin, 0.04 mg; riboflavin, 0.02 mg ; niacin, 0.1 mg; Vitamin C, 7 mg, 30 mg; iron, 0.5 mg; magnesium, 16.5 mg; potassium, 150 mg; and sodium, 7 mg.

Research has found that *allium* species which includes onion may help to put a stop to tumour growth, cardiovascular diseases, aging and all processes that are linked with free radicals (Stajner, Milic, Candanovic-Brunet, Kapor, Stajner & Popovic, 2006). Onions contain sulphur compounds which help in lowering the risk of cardiovascular diseases. The sulphur compounds; chromium and vitamin B6 decrease the homocysteine level which is a risk factor in heart attack, stroke and heart disease patients.

According to Block (1978), the consumption of onion deals with hyperglycaemia and hyperlipemia. This therefore implies that the more the consumption of onion products, in other words, foods containing more onion will be of help to the individual or the household that depends on the food products. The rate at which a child or infant fall, sick or with other medical issues may reduce to some extent provided the parents feed the child with complementary food having onion in its content.

Proximate Composition of Onion

Yalcin and Kavuncuoglu (2014) conducted a study to investigate some physico-chemical and antioxidant properties, volatile compounds and fatty acid composition of ten different onion seeds. The fatty acid composition and volatile compounds were analyzed by gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS), respectively. Physico-chemical analysis showed that onion seeds possessed high amount of oil 21.86 %-25.86 % and crude protein 15.7 %-26.1 %. Gas chromatography (GC) results revealed that onion seed oil was rich in linoleic acid 49.42-60.66 % which was followed by oleic and palmitic acid, respectively.

Dini, Tenore and Dini (2008b) also studied red onion seeds and they found 10.5 % moisture, 20.4 % oil, 24.8 % crude protein in these seeds. Onion bulbs represent a source of cysteine derivatives, which make them a functional food, but onion seeds contain only low concentration of these components.

A study was conducted to investigate the proximate composition, mineral composition and energy value of red onions of Bangladeshi and Indian origin. Results showed that, both Bangladeshi and Indian onions have high amount of moisture 82.99 % and 82.77 %, carbohydrate 14.146 % and 14.772 %, total Sugar 4.74 % and 2.32 %, vitamin-C 6.5 mg and 5.7 mg, calcuim 46.9 mg and 25.7 mg, phosphorus 50.6 mg and 30.3 mg and potassium 140 mg and 129 mg respectively. The level of protein 2.62 % and 1.489 %, fat 0.4 % and 0.721 %, iron 0.6 mg and 0.24 mg, copper 0.04 mg and 0.1 mg, manganese 0.2 mg and 0.14 mg and zinc 0.2 mg and 0.4 mg are comparatively lower in the varieties. The result obtained confirmed the usefulness and utility of onion bulbs of both varieties. The result also suggests that Bangladeshi onion having adequate quantity of vitamins and minerals with potentials to meet the nutritional requirements of human health is better than the onion of Indian origin (Shovon, Abida, Muhammad, Muhammed & Ahtashom, 2013). According to Edet, Eseyin and Aniebiet (2015), onion contains calcium, magnesium, manganese, potassium, phosphorus, soidum and iron. These minerals make it a good source of ingredients for bone, teeth and muscle growth hence including it in the preparation of meals would be benefical to the household.

Origin and Distribution of Anchovies

Anchovies are small, tiny and silver salt water fish, which belongs to the *Engraulidae* and *Anchoa* family. There are about 145 species in 17 genera, found in the Atlantic, Indian, and Mediterranean Sea and Pacific Oceans (Sankar, Anandan, Mathew, Asha, Lakshmanan, Varkey, Aneesh & Mohanty, 2013). Anchovies are usually classified as an oily fish (Food Standards Agency, 2004; Nina Tabitha & Gunalan, 2012). To many people, the taste of anchovies is not pleasant but it is excellent for people with certain health conditions such as hypertension. In Ghana, anchovies are consumed in various forms: fresh, smoked dried or sun dried (Edusei, Aseidu, Sakyi-Dawson & Owusu, 2004).

Nutritional and Health Benefits of Anchovies

Anchovies are rich in omega-3 oils, calcium and iron (Siriskar, Khedkar & Lior, 2013). It is a highly nutritious fish and a valuable source of high quality protein, which is superior compared to that of meat and egg (Kader, 2005). It contains high amount of proteins, vitamins and minerals that assist in maintaining good health. Minerals such as calcium, iron, magnesium, phosphorus, potassium, sodium and zinc can also be obtained from consuming anchovies. According to Saglik and Imre (2001), anchovies supply the body with vitamins such as thiamine, riboflavin, niacin, folate, vitamin C, vitamin B12, vitamin B6, vitamin A, vitamin E and vitamin K.

It contains fatty acids and cholesterol. However, anchovies have the ability of maintaining a healthy heart, lowering the levels of bad cholesterol and toxins. It also assists in recovering a healthy skin, aids weight loss and the development of strong and healthy teeth. The consumption of anchovies also lowers the risk of osteoporosis and mascular degeneration (Saglik & Imre, 2001). This implies that consumption of complementary foods containing anchovies if fed by the parents to the infants will help in the development of strong teeth and bones, reduce osteoporosis, boost the immune system and also help in maintaining a healthy heart of the infants.

Proximate Composition of Anchovies

A study by Edusei *et al*. (2004) provided guidelines for consumers and dieticians. In this study quality protein maize and anchovies were analyzed. The analysis showed that anchovies contained moisture content of 6.5%, Protein of 72.2%, fat 4.1%, crude fibre 0.8%, ash 9.3% and carbohydrate 7.2%.

Bereket, Melake, Abdu, Habte-Michael, Habtamu & Nabil Qaid, (2017) conducted a study to determine and compare quality of dried anchovy by solar tent and open sun rack drying methods and to adopt improved method to get better quality of dried anchovies. The study found that quality of the fish products dried in the solar tent drier was superior compared to that of open sun rack-dried products. The average moisture, crude protein, total lipids, and ash content of the solar tent dried products were 7.5 %, 79.32%, 3.74% and

9.90%, and for open sun rack were 7.7% 75.32%, 3.20% and 9.20%, respectively.

Šimat and Bogdanović (2012) in a study have found that the chemical composition of fish varies greatly depending on the starvation and intensive food intake periods and other external factors such as sea temperature. The proximate composition analysis of the edible portion of anchovy were investigated over a period of two years and the result showed that the average proximate composition of anchovy caught in the Adriatic Sea was as follows: water content 76.52 ± 1.38 %, protein content 21.34 ± 0.29 %, fat content 2.27 ± 1.20 %, ash content 1.42 ± 0.08 %.

A study to assess proximate composition, amino acid profile, fatty acid composition and mineral status of Commerson's anchovy (Stolephorus commersonii) in three different size groups (3-5g,6-10g,25-30g) was conducted (Sankar *et al.,* 2013). The moisture content was found to be high in big size group and low in small size group. However, the fat content was found to be high in small size group and low in big size group showing an inverse relation between moisture content and fat content (Sankar *et al.*, 2013). The study further revealed that the protein content was high in medium sized fish. The mineral content was found higher in small sized fishes.

The size groups 3-5g recorded moisture content of 76.47±0.36, protein content of 14.71 ±0.39, fat 2.41±0.20 and ash level of 6.63±0.33, 6-10g size group recorded moisture content of 76.97±0.59, protein content was 16.95±0.27, fat content of 1.97±0.14 and ash content of 4.02±0.08 whiles the 25-30g contained moisture content of 80.65±0.29, protein content of 15.71±0.34, fat of 1.25±0.10 and ash content of 2.40±0.46. Sankar *et al.*

(2013) concluded that anchovy can be a cheap and ideal dietary supplement for children and the elderly. This can be attested to in Ghana especially Cape Coast which is a coastal town. Most of the natives are fisher folks hence getting anchovy would not be difficult for mothers to use in feeding their babies.

Effects of Drying on Foods

Drying is one of the oldest methods of processing and preserving food. Drying can be defined as a process of moisture removal due to simultaneous heat and mass transfer (Ertekin & Yaldiz, 2004). Drying is carried out to minimise the water level to one at which microbial spoilage and deterioration reactions are greatly reduced (Akpinar & Bicer, 2004). Sun, oven, and solar drying are the most frequently used methods; sun drying is the most common method practiced (Matazu & Haroun, 2004) but, the dried product can be affected by contamination from insects, dust, or spoilage resulting from rain during drying **(**Lahsasni, Kouhila, Mahrouz, Mohamed & Agorram, 2004). Presently hot air oven drying is the most commonly used method of drying agricultural products. Doymaz (2004) reported that products that are dried using oven drying produce a more uniform, hygienic and attractively coloured dried product. According to Ogunlakin *et al*. (2012), oven drying methods have better effect on nutritional and functional properties of cocoyam flour than direct sun drying method.

During the period of drying, there is the addition of heat and the elimination of moisture from the food. Several changes take place which affect the nutrient contents of food in various ways; it can either increase the concentration of some nutrients by making them more available or decrease the concentration of some nutrients (Hassan, Umar, Maishanu, Matazu, Faruk & Sanni, 2007; Morris, Barnett & Burrows, 2004; Ladan, Abubakar & Lawal, 1997). For instance vitamin C is lost (Perera, 2005) and changes of colour and appearance which may not be desirable (Kendall, DiPersio & Sofos, 2004). Moderate losses of B vitamins also occur during drying.

According to Baysal, Icier, Ersus and Yıldız (2003), the structural and physico-chemical changes that take place affect the final product quality. According to Krokida and Maroulis (2001) drying method and processing conditions affect significantly the colour, texture, nutritional content, density and porosity and sorption characteristics of the material so the raw material may end up as a completely different product depending on the type of drying method and conditions applied. According to Sablani (2006) losses of nutrients can be reduced by applying pretreatments such as blanching, selection of appropriate dying methods and optimization of drying conditions.

Beta (β) Carotene and Its Roles in Human Nutrition

Beta (β) carotene, the vitamin A precursor is obtained from plant foods. It is a bright orange pigment which is found in vegetables such as carrots, cantaloupe, melons, sweet potatoes and dark vegetables and fruits such as green, leafy vegetables. When eaten it is converted to vitamin A (Mitchell, 2011). Vitamin A plays an important role in the life of infants. It is needed in minute amounts for its main functioning in the visual cycle in the retina of the eye, but it also plays an important role in growth, development, reproduction and in the immune system (Tariku *et al*., 2016). Children from 0-59 months of age require 250 to 300 µg of Vitamin A (FAO/WHO, 1967). An insufficiency of vitamin A in diet results in Vitamin A deficiency (VAD) and is responsible for night blindness, increased susceptibility to infections and impaired growth and development (Sommer, 1998). Excess β carotene is not associated with major adverse effects it is converted to antioxidant which helps in fighting cancer (Mitchell, 2011).

Complementary Foods

After the first 6 months of an infant's life, breast milk alone cannot provide the full nutritional requirements thereby creating a gap which keeps expanding with the increasing age of the infants (WHO/UNICEF, 2003). Complementary feeding plays a vital role in bridging these gaps. According to USDA (2009), in order to fill those nutritional gaps, infants should be introduced to complementary foods (foods other than breast milk or infant formula).

Complementary foods can be defined as foods and liquids other than breast milk or infant formulas that are given to infants after the first six months of their lives for both nutritional and developmental reasons and also to enable transition from milk feeding to family foods (Koletzko, Cooper, Makrides, Garza, Uauy & Wang, 2008). The target range for complementary feeding is generally taken to be 6 to 24 months of age (WHO, 2003), even though breastfeeding may continue beyond two years (PAHO/WHO, 2002).

According to UNICEF (2011), complementary foods should be high in energy density with protein which contains all essential amino acids, the required vitamins (A, C and K) and minerals (iron, folic acid, and calcuim) with no antinutritional components, and while retaining the qualities for palatability. Complementary foods play a very important role in the development of children (Amankwah, Barimah, Nuamah, Oldham & Nanaji, 2009). According to Codex Alimantarius Commission, CAC (2008), complementary foods should be of appropriate nutritional quality and energy to balance the nutrients obtained from breast milk for infants and family foods for younger children. Infants need nutritionally balanced, calorie-dense complementary foods in addition to mother’s milk because of the increasing nutritional demands of the growing body (Sajilata, Singhal & Kulkarni, 2002: Umeta, West, Verhoef & Hautvast, 2003). According to Prasad and Kochhar (2016) an ideal complementary food must be nutritionally densed, easily digestible, of suitable consistency and affordable to the consumers.

According to World Bank (2005) stunted growth which occurs as a result of malnutrition during this period is difficult to reverse after two years of age. The quality of complementary foods given to a baby has been found to be very critical to mental growth of that baby, because the brain develops rapidly from 5 months before birth to 10 months after birth. At the end of the first year of life, the brain is fully developed and has attained 70% of its adult weight (Wardlaw & Insel, 2000). Malnutrition in early childhood impairs cognitive functioning which has an impact on the educational attainment of children later in life (Grantham-McGregor, Cheung, Cueto, Glewwe, Richter & Strupp, 2007).

Complementary foods are expected to have adequate energy density to provide a growing child with daily energy requirement. For complementary foods the amount (gram or volume) needed to provide energy requirement is 200–333 g/day for 6- to 8-month-old, 300–500 g/day for 9- to 11-month-old, and 550–917 g/day for 12- to 23-month-old children (Abeshu *et al.,* 2016). However, the amount required to cover the energy gap corresponds to the level of energy density in the diets served (WHO, 2009). A complementary food low in energy density results in protein energy malnutrition (Daelmans & Saadeh, 2003). Protein is considered as an important nutrient in complementary foods. They are the major sources of essential amino acids and energy in times of energy deficiency (Abeshu *et al.,* 2016). When average breast-milk intake is assumed, the amount of protein needed from complementary foods is 1.9 g/day at 6–8 months (21%), 4.0 g/day at 9–11 months (42%), and 6.2 g/day (57%) at 12–23 months (Dewey, 2001; WHO, 2001; WHO/UNICEF, 1998). The ability of a complementary food to meet up the protein-energy needs of infants depends on its nutritional quality (Kamchan, Puwastien, Sirichakwal & Kongkachuichai, 2004).

Fat is vital in the diets of infants because it provides essential fatty acids, aids in the absorption of fat soluble vitamins such as A, D, E and K, and enhances dietary energy density and sensory qualities (Pan American Health Organization (PAHO) and World Health Organization (WHO, 2001). Mitchell (2011) also highlight that fat enhances the taste, texture and smell of many food, making them more appetising. Fat together with carbohydrates supply the energy needs of the infants (WHO, 2001; Monte & Giugliani, 2004).

When adequate breast milk is consumed, the amount of fat required from complementary food is 0 g/day (0%) at 6–8 months, 3 g/day (5–8%) at 9–11 months, and 9–13 g/day (15–20%) at 12–23 months (WHO, 2001). A high fat content in a complementary food provides more energy to the infant. However, if it exceeds the desirable level, it would be disadvantageous for stability of the product as the unsaturated fatty acids are vulnerable to oxidative rancidity (Lohia & Udipi, 2015) that would shorten its shelf life. The decrease in fat content could be an advantage to health as well as extending product shelf life as reported by Saskia and Martin (2008). According to Dietz and Robinson (2005) excessive fat intake predisposes infants' childhood obesity and subsequently cardiovascular diseases as well as increasing micronutrient malnutrition in infants PAHO/WHO (2002).

According to Agostoni, Riva and Giovannini (1995); Brooks, Mongeau, Deeks and Lampi (2006), dietary fiber has several health benefits during early and future lives of a child. Although crude fibre does not supply nutrients to the body, it adds bulk to food thus facilitates bowel movements (peristalsis) and prevents lots of gastrointestinal diseases in man (Gordon, 1999). Brooks *et al* (2006) indicate that it is essential for infants to be fed with complementary foods that contain adequate dietary fibers so that tastes and eating patterns become established as early as possible. Fibres should therefore be introduced gradually into the diet of infants from the age of 6 months, but they should consume a very low-fiber diet. High-fibre foods in effect give satiation by filling the stomach and delaying the assimilation of nutrients **(**Rolfes, Pinna & Whitney, 2008). Abeshu *et al*. (2016) also assert that increasing the intake of dietary fibre increases stool bulk, causes flatulence, and decreases appetite. According to Ijarotimi and Keshinro (2013) low crude fibre content may encourage infants to eat more nutrient dense food that may contribute in meeting their daily energy need and other essential nutrient(s) requirements. Excessive dietary fibre in complementary foods may have undesirable effects such as lower caloric density and irritation of the gut mucosa (Asma, El Fadil & El Tinay, 2006). According to Mullin, Rosa and

Reynolds (1994) about 25-50% of fibre in sweet potato is soluble this therefore makes sweet potato a suitable ingredient for complementary food.

Kavitha and Parimalavalli (2014) highlight that the ash content present in food indicates the level of minerals present. Minerals play critical roles in the lives of infants and young children.They help in building strong teeth and bones, functioning of muscles and nerves, blood clotting, boosting of the body's immune system and promoting proper functioning of other organs of the body (Whitney, Hamilton & Rolfes, 1990). Solomon (2005) is of the view that, moisture content in complementary food powders is very important as high moisture content encourages microbial growth. According to Approved methods of American Association of Cereal Chemists (AACC) (2000), moisture level above 14.5% encourages microbial growth causing deterioration to flour. However, Shahzadi, Butt, Rehman and Sharif (2005), reiterate that flour products with moisture content less that 13% are more secured from deterioration caused by moisture.

The Protein Advisory Group (PAG, 1971) guidelines for complementary foods, indicates that protein content should be 20%, fat content up to 10%, the moisture content should be from 5% to 10%, total ash content should not be more than 5% and carbohydrate 65% of the complementary food. The World Health Organization and Food and Agriculture Organization of the United Nations (WHO/FAO, 2004) also recommend that the required daily allowance for protein content in complementary food should be ≥ 15 %, fat should range from 10 to 25%.

According to Rama and Venkat (1995) cereals do not contain vitamin A or Vitamin C, however owing to good nutritional value, low price and year round availability, roots and tubers offer good alternate or improvement to cereal-based complementary foods to reduce the incidence of malnutrition among children (Adenuga, 2010).

Proximate Analysis of Complementary Foods

Several complementary foods have been formulated using different ingredients and methods. The following are some of the results of proximate analysis conducted on complementary foods.

Fikiru, Bultosa, Forsido and Temesgen (2017), formulate and analysed 14 complementary foods using maize, roasted pea and malted barley. The moisture content of the complementary food ranged from 5.0-6.5%, protein 13-18.5, crude fat 3.1-4.1%, ash 1.5-2.5 and carbohydrate 68.9-74.1%. The proximate analysis indicates that the ash and carbohydrate contents found in the complementary foods were within the standards set by WHO/FAO (2004). This therefore implies that if infants are fed with such complementary food, the energy obtained from the food would be enough for the rigorous activities of the infants.

Mbaeyi-Nwaoha and Obetta (2016) formulated a complementary food from millet, pigeon pea and seedless breadfruit leaf powder blends and analyzed for its proximate analysis. The complementary food had moisture content ranging from $3.39^{d}\pm0.060$ - $4.78^{a}\pm0.090$, protein $14.59^{d}\pm0$. 250 - $24.27^{a}\pm0.580$, fat $1.21^{c}\pm0.020$-$4.85^{a}\pm0.035$, ash $2.51^{d}\pm0.015$-$4.46^{a}\pm0.245$ crude fibre $4.76^{c}\pm0.135$-$11.51^{a}\pm0.230$ and carbohydrate $54.87^{a}\pm0.295$-$71.17^{a}\pm0.015$. The 11.51% of fibre content in the complementary food is too high for infants as this may lower the amount of nutrients to be absorbed and also reduce the amount of food to be consumed since infants have small stomachs.

A complementary food which was formulated from wheat and groundnut was found to contain moisture content of 8.56±0.40%, ash content of 1.88±0.19%, protein of 18.45±0.66%, fat of 31.22±0.95%, fibre 2.49± 0.18% and carbohydrate of 37.40±1.72% (Ikese, Ubwa, Adoga, Lenka, Inalegwu *et al.,* 2016). Looking at the proximate analysis it can be seen that the carbohydrate content was below the standard set by WHO/FAO (2004) which was supposed to be ≥ 65% but the fat content was high enough to supply the infants with the energy needed for growth and development.

Lohia and Udipi (2015) formulated complementary food mixes using fermented and malted cereals and pulses (wheat, rice, ragi and lentil). The fermented formulated food mixes had the following amount of nutrients moisture 7.1±0.7%, ash1.3±0.2% crude fibre 3.7±0.01 crude protein 10.7±0.1 fat 12.0±0.02 carbohydrate 68.8±0.9. The malted food mix had the following recordings moisture 4.3±0.1 ash 1.2±0.03 crude fibre1.5±0.01 crude protein 11.5±0.2 fat 11.7±0.01 carbohydrate 71.2±0.3. The proximate analysis of the two food mixes shows the malting process increased the protein and carbohydrate content of food therefore can be recommended for infant complementary foods since protein and carbohydrates are needed by infants for growth and development.

Shiriki, Igyor and Gernah (2015), evaluated the nutritional content of complementary food from maize, soyabean and peanut fortified with moringa oleifera leaf powder. Through proximate analysis the following amount of nutrients were recorded in the complementary food, moisture content ranged from $7.06^{d}\pm0.01$-$7.51^{a}\pm0.02$, protein $16.04^{d}\pm0.02$-$17.59^{b}\pm0.01$, fat $20.80^{d}\pm0.01$-$23.48^{a}\pm0.01$, fibre 2.25^{d} ±0.02-$4.42^{a}\pm0.02$, ash $1.40^{c}\pm0.01$-$2.50^{b}\pm0.01$ and carbohydrate $47.63^{c}\pm0.03$-$49.32^{b}\pm0.02$.

Onoja, Akubor, Gernar and Chinmma (2014) formulated a complementary food using sorghum, soya bean, and plantain flour. The following amounts of nutrients were recorded in the complementary food. The moisture content ranged from 46.36 ± 0.02^{a}-50.41 ± 0.01%, fat 5.09 ± 0.01^{a}-7.13 ± 0.01%, protein 11.17 ± 0.01^{a}-14.21 ± 0.00%, ash 3.30 ± 0.01^{a}-3.48 ± 0.01%, fibre 2.23 ± 0.01^{a}-2.27 ± 0.02% and carbohydrate 30.10 ± 0.01^{a}-$32.87\pm$ 0.01%. This therefore implies that the moisture content of the food is high which may affect the keeping qualities of the food

Ojinnaka, Ebinyasi, Ihemeje and Okorie (2013) formulated a complementary food from blends of soybean flour and ginger modified cocoyam starch. They detected a protein content of $2.68^{d}\pm0.08^{d}$-$3.97^{a}\pm0.08$ ash $0.23^{a}\pm0.02^{a}$-$0.57^{a}\pm0.01$, fibre $0.81^{d}\pm0.04$-$1.11^{a}\pm0.02$, fat $1.22^{d}\pm0.02^{d}$-$1.93^{a}\pm0.02$ and carbohydrate $78.55^{a}\pm0.12^{a}$-$80.87^{a}\pm0.05$. The moisture content ranged from $11.55^{ab}\pm0.20$-$16.51^{a}\pm0.03$. The moisture content of the complementary food was too high and above 14.5% recommended by AACC, (2000) which promoted microbial growth and could cause deterioration of flour. However the complementary food was energy densed which was suitable for infants as they need a lot of energy to grow.

Nandutu and Howell (2009) analyzed two orange fleshed sweet potato formulations, recipe A had a moisture content of 8.0±0.4 carbohydrate 66.0 ±0.2 protein 20.4±0.1 fat 2.0±0.1 ash 3.2±0.8 while the recipe B had Moisture content of 8.4±0.6 carbohydrate 58±1.4 protein 28.0±0.4 fat 3.4±0.5 ash 2.0±

0.0 g/100g dry weigh. This therefore shows that the complementary foods formulated contained the necessary nutrients needed for growth and development by infant but the B carotene content was not determined or should have been determined since orange fleshed sweet potatoes is known to be rich in β carotene.

Solomon (2005) formulated a complementary food using dehulled rice, groundnuts, bambara nut, acha grain, benni seed, Crayfish, garden egg, yellow maize, and soya beans. The following nutrients were found in the complementary food. Moisture content ranged from 3.70±0.14-5.15±0.08%, ash 2.05±0.07-2.60±0.14%, crude protein 13.31±0.22-35.6±1.28% crude fat 15.6±0.2-38.1±0.57%, crude fibre 9.07±0.26-10.8±0.35% and energy (Kcal) 473.9±16.19-598.5±14.24. Looking at the results of the analysiss, the formulated food has high moisture content which may affect its storage.

Functional Characteristics of Complementary Food

Functional characteristics are those properties that determine the behaviour of nutrients in food during processing, storage and preparation because they affect the general quality of foods as well as their acceptability. Functional properties establish the purpose and use of food items for various food products. Ponzio, Puppo and Ferrero (2008) report that functional properties of flours have also been related with some essential qualities of products produced from these flours.These also determine their end use in food applications.

Processing conditions have been shown to influence functional properties of flour. According to Osundahunsi Fagbemi, Kesselman and Shimoni (2003); Aina, Falade, Akingbala and Titus (2009), factors such as variety, processing steps (van Hal, 2000), processing methods such as parboiling (Osundahunsi *et al.* 2003), blanching (Jangchud, Phimolsiripol and Haruthaithanasan, 2003), drying techniques (Yadav, Guha, Tharanathan and Ramteke, 2006), and peeling, pre-treatment and drying temperatures (Maruf, Akter Mst, and Jong-Bang, 2010a), have been found to have effect on the quality of sweet potato flour produced. Some of the functional properties include; water absorption capacity, oil absorption capacity, bulk density, foaming properties (capacity and stability), and swelling power or capacity, water solubility index, emulsifying capacity or emulsion activity/stability. The functional properties of food proteins play an important role in food processing and formulation of food products. If complementary food is to be considered for product development then the functional properties should be looked at.

Bulk Density

Bulk density is an essential property in many food applications, due to its ability to help determine the ease of packaging and transportation of food products. Olaitan, Eke & Uja (2014) highlight that bulk density also assesses heaviness of flour. It is affected by moisture content and particle size of the flour (Onimawo & Egbekun 1998). According to Okorie, Okoli and Ndie (2011), bulk density depends on the particle size of the ingredients, as smaller particle sizes are associated with lower bulk density. Increase in bulk density is desirable because it offers greater packaging advantage, as a greater quantity may be packed within a constant volume (Fagbemi, 1999). Mburu, Gikonyo, Kenji and Mwasaru (2011), asserted that low bulk density is a benefit in the formulation of baby foods where high nutrient density to low bulk is desired.

Akubor, Yusuf, and Obiegunam (2013) report that lower bulk densities are considered best for complementary food as foods prepared from low density food items are easily digested by infants' while retaining the nutrients.

Many researchers have reported of the following bulk densities in their formulated complementary food; Laryea (2016) reports of a lower 0.787 to 0.827 bulk density in his complementary food from orange fleshed sweet potato, millet flour and soya bean flour. This implies that the ingredients flour had smaller particle sizes. Lohia and Udipi (2015) report 0.68±0.01 in their malted food mix and 0.73±0.02 in fermented food mix developed from cereals and pulses. This means that malted foods produced small flour particles than the fermented foods.

Ghasemzadeh and Ghavidel (2011) record a bulk density range of 59.4 to 62.5 for their 4 complementary foods formulated from cereals and legumes. Mbaeyi-Nwaoha and Obetta (2016) record bulk density range from 0.54±0.150 to 0.65 ±0.001 in complementary food from millet, pigeon pea and seedless breadfruit leaf powder blends. This means that smaller quantity may be filled within a constant volume. Onoja, Akubor, Gernar and Chinmma (2014) record bulk density `range from 0.42 ± 0.02 to 0.46 ± 0.02 from their complementary food from fermented sorghum, soybean and plantain.

Swelling Power

Swelling power is a sign of water absorption index of granules during heating (Loos, Hood & Graham, 1981). Adeleke and Odedeji (2010) report that swelling power is influenced by protein content of the food samples. Kinsella (1976) and Ayo-Omogie and Ogunsakin (2013) both report that swelling causes changes in hydrodynamic proteins of food. This brings about characteristics such as body, thickening and increase in viscosity to food. According to Afam-Anene and Ahiarakwem (2014), a lower swelling capacity of complementary foods is advantageous in feeding infants. This increases the nutrient density of the food thereby enabling the child to consume more in order to meet his/her nutrient requirement. Laryea (2016) reported of swelling power of 6.652 to 7.734. Complementary foods with lower swelling power are easily digestible by infants (Okorie *et al.*, 2011). Fasuan, Fawale, Enwerem, Uche and Ayodele (2017) reported swelling index of 129-131.75% from complementary food from cereal, oilseed and animal polypeptide. Ikese *et al*. (2016) report swelling index range of 23.08 to 24.10 in wheat and groundnut complementary food. Mbaeyi-Nwaoha and Obetta (2016) record 2.25±0.695 to 3.16±4.876 in their complementary food. Ojinnaka *et al.* (2013) prepared complementary food porridges from blends of soybean flour and ginger modified cocoyam starch and recorded a swelling power of 2.56±0.05 to 3.03±0.04.

Water absorption Capacity

Water absorption capacity (WAC) measures the ability of flour to absorb water and swell for improved consistency in food. It also gives an index of the amount of water retained within the protein matrix which shows the functional capacity of the product protein in thickening and food formulations (Mburu *et al.*, 2011). It is a property desirable in food systems because it helps to improve yield, consistency and give body to the food (Osundahunsi *et al.,* 2003). According to Mburu *et al.* (2011), water absorption capacity is an essential characterstics of flours because functional properties such as viscosity and gelation are dependent on it and gives important information on the behaviour of complementary food products during reconstitution in hot or cold water.

Fasuan *et al.* (2017) recorded water absorption capacity of 39-96% in their complementary food from cereal, oil seed and animal polypeptide. Ikese *et al*. (2016) reported water absorption capacity of 6.50 to 7.10 from their wheat and groundnut complementary food whilst Laryea (2016) recorded water absorption capacity range from 152.5 to 216.7 % for his sweet potato based complementary food.

Ghasemzadeh and Ghavidel (2011) formulated four (4) complementary foods from cereals and legumes and recorded water absorption capacity to range from 465 to 530%. In a similar study, Lohia and Udipi (2015) report 0.33±0.05 for malted mix and 0.35±0.05 for the fermented mix. Onoja *et al.,* (2014) also record a range from 50.00±0.02 to 74.34±2.40.

Solubility

Solubility is an index of protein functionality such as denaturation and its potential application (Adepeju *et al.*, 2014). Solubility of starch depends on the origin and type. The ability of food commodities to absorb water is sometimes attributed to their protein content (Kinsella, 1976). Rickard, Asaoka and Blanshard (1991), report that the temperature of an aqueous suspension of starch is raised above the gelatinization range, hydrogen bonds holding the starch granules continue to be disrupted. Water molecules become attached to the liberated hydroxyl groups and the granules continue to swell, and as a direct result of swelling, there is a parallel increase in starch solubility. Adepeju *et al.* (2014) record lower solubility index, ranging from

3.27±0.45 to 4.9±0.26 in their breadfruit based complementary food whiles Laryea (2016) report an index range from 17.78% to 20.32%.

Complementary foods developed from sweet potatoes

Several complementary foods have been developed using various staple foods. In Ghana complementary foods are mostly produced from cereals (Amagloh, Weber, Brough, Hardacre, Mutukumira & Coad, 2012a). According to Ugwu (2009), complementary foods can be formulated from roots and tubers such as sweet potatoes due to their high energy content. Sweet potatoes have used in the development of complementary foods at both household levels and industrial levels have been reported in literature:

Nnam (2000), formulated complementary food from cereal (maize or sorghum) 65%-legume (soya bean or cowpea) 30%-sweet potato 5%. The raw ingredients were processed either by malting or cooking or fermentation, followed by drying and milling into separate fine flours which were then blended. The multimixes contained fair quantities of calcium and phosphorus and an adequate amount of some of the essential amino acids. The complementary food formulated satisfied the specifications of Codex Standard for infants' foods (Codex Alimentarius Commission, 1991), but in the formulation sweet potato was not the main ingredients. This means that infants fed with this complementary food would obtain the right nutrients and also strong teeth and bones needed for growth and development.

Akaninwor and Okechukwu (2006) also report on the analysis of processed sweet potato-crayfish-soya bean and sweet potato-crayfish-bambara groundnut supplementary foods. In this work the red fleshed variety of sweet potato was used. The formulations for this work were based on a total calories range of 353-391 kCal/100kg and the formulations control (Nutrend® brand) were fed to rats. They report an increase in weight and organ (heart and liver) after the diets were consumed. This work was a continuation of the work done in 2004, where the nutrient and anti-nutrient contents of formulated complementary foods and commercial complementary foods were compared. This implies that it can be used as a perfect body buiding food for infants who may be wasting.

Nandutu and Howell (2009) report on the nutritional and rheological properties of sweet potato-based infant food and its preservation using antioxidants. The orange-fleshed sweet potato (SPK 004) was used in this work. The formulation was done using the Micro diet programme version 1. In this work, sweet potato was the main ingredients used for the two formulations. The nutritional and rheological properties of the formulated complementary foods were compared with two commercial complementary foods (Cerelac® and Heinz baby food) used in Uganda. The mean ± SD for moisture, total carbohydrate, protein, crude fat, and ash per 100 g dry weight were 8±0.4, 66±0.2, 20.4±0.1, 2.0±0.1, 3.2±0.8 g, respectively for recipe A, and 8.4±0.6, 58±1.4, 28±0.4, and 3.4±0.5, 2.0± 0.0 g, respectively for recipe B.

The Study of Nandutu and Howell (2009), found out that the formulated food was within the accepted consistency (<500Pa) after heating and cooling. The digestibility of the formulated complementary foods was also assessed and it ranged from 64.9% for Cerelac® to 69.5% for one of the recipes developed. It implies that infants weaned with this complementary food will get the right nutrients for growth and development and also having the right consistency will help the infants eat the required amount of food well and also obtain the maximum nutrients needed for growth thereby preventing malnutrition of any form.

Sanoussi, Dansi, Bokossa-yaou, Dansi, Egounlety, Sanni and Sanni, (2013), developed another sweet potato-based complementary food. The purpose of their work was to add value to sweet potato in order to help achieve food security in Benin. Two varieties of sweet potatoes were used in the study; yellow-fleshed and orange-fleshed sweet potato. Two formulations were made from Sweet potato blended with soya bean at 25 and 50%. The Minitab software was used to optimize the formulations in order to achieve a protein range of 16.9 to 22 g/100g and fat content of 6 to 10 g/100g recommended by WHO/FAO and Codex Alimentarius Commission guidelines in 1991. From the study, it was reported that there was no significant difference in colour. The 50:50 orange-fleshed sweet potato and soya bean formulation was the only formulation that was observed to be consistent to the FAO/WHO standards.

In 2014, Bonsi, Plahar and Zabawa formulated complementary foods using orange-fleshed sweet potato to improve the nutritional content of some complementary foods. In their research, orange-fleshed sweetpotato was added to already known cereal-legume weaning food (roasted maize-soy blend and fermented maize-soy blend). The purpose of their work was to improve on the nutritional content (vitamin A) of the food blend in order to help with the mitigation of vitamin A deficiency. The higher the orange-fleshed sweetpotato content, the higher the vitamin A content. Complementary food containing 25% sweet potato portion provided a β-carotene content of 66.47 µg/g whereas 50% sweet potato portion resulted in almost twice the amount (115.55μg/g). This means if this complementary food is promoted and fed to infants it may help reduce the prevalence of vitamin A deficiency which is on the rise in Ghana.

Laryea (2016) formulated a complementary food from of orange fleshed sweet potato, millet and soya bean flours using the drum drying method. The purpose of the study was to help alleviate vitamin A deficiency in Ghana and also enhance the use of orange fleshed sweet potato to help achieve food and nutrient security.

In the study, the functional, pasting and the colour of the formulated complementary foods were determined. It was reported that the most preferred formulation was the blend with 50% OFSP, 15% millet and 35% Soya bean flours. The most preferred formulation was significantly ($p<0.05$) higher in protein (16.96%) and β-carotene (0.53 mg/100g) content than the control complementary foods, which was maize-based. Ash and fat were comparable to that of a commercial complementary food. In addition, the most preferred formulation a significantly higher iron and potassium content compared with two commercial complementary foods.

Food Product Development

Food product development is a process of developing new food products or improving upon existing ones for consumption. It is considered as a very significant procedure in the Food Industry (Earle, Earle, & Anderson, 2001). According to Stewart-Knox and Mitchell (2003), it is essential, if the food industry will want to survive in the current food market competitions. To the food industry, its absence will lead to failure. Thus, food industries without food product development or process will have to compete on the market based on price alone, which will in tend favour only the industry with the lowest cost inputs.

According to Rudder, Ainsworth and Holgate (2001), the process of food product development comprise stages that include ideas and concept generation, screening, research, development, product testing and marketing launch activities. Carpenter, Lyon and Hasdell, (2000) have also reported that sensory analysis is one key aspect of food product development. Therefore a product may be nutritious, healthy, convenient and safe for consumption, but as long as it does not appeal to the sensory qualities of consumers, such a product will fail. Sensory evaluation is also used to select the most preferred product out of the different formulations developed in order to meet the consumers' sensory qualities.

Sensory Evaluation

Sensory evaluation is a scientific discipline used to evoke measure, analyze and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing (Stone & Sidel, 1993). The characteristics of food are perceived by the five senses; sight, smell, taste, sound and touch. Sensory evaluation is important in the food industry. According to Institute of Food Technologists (IFT) (1981), sensory evaluation is useful in the development of a new product, product matching, product upgrading, process modification, cost cutback, selection of a new source of supply, quality control, storage stability, product grading and rating, consumer acceptance and/or opinions, consumer preference, panellist selection and training.

There are many types of sensory evaluation methods, but the most commonly used methods are the difference tests, descriptive analysis and consumer acceptance tests (Lawless & Heymann, 1998). Difference tests estimate the extent of sensory differences between samples. Consumer acceptance, preference, and hedonic (degree of liking) tests are used to establish the level of consumer acceptance for a product. Product acceptance can be determined using the category scales, ranking tests and the paired-comparison test. Sensory characteristics such as colour, flavour, aroma and texture are powerful determinants in food acceptability. In the food industry, colour and appearance have become important criteria in terms of how it is presented because it has effects on the appetite of consumers. According to Spence (2015), food colour plays an essential function in driving liking and the consumer acceptability of a variety of food products. However, Singh-Ackbarali and Maharaj (2014) also highlight that colour and appearance are indices of the inherent good quality of foods associated with acceptability, as they can arouse or inhibit consumer appetite.

CHAPTER THREE

RESEARCH METHODS

This chapter presents the research design, population, sample size, sampling procedure, research instrument and data analysis used. The chapter also describes the methods, procedure and techniques that were used in the study.

Study Area

The Study area was Cape Coast which is predominantly occupied by fishing activities and merchandising. It is the regional capital of Central Region. Cape Coast Metropolies is bordered by the Gulf of Guinea to the south, Komenda /Edina/ Eguafo /Abirem Municipality to the West, Abura /Asebu/Kwamankese District to the east and Twifo /Heman /Lower Denkyira District to the north.

Research Design

Experimental research is the intentional manipulation of variables as determined by the researcher to see the cause and effect. The treatment or manipulation of the variables causes change or otherwise on the independent variable (Fisher, 1991). In order to determine the various influences of the anchovy and orange fleshed sweet potato at a varying quantity in terms on their sensory properities (taste, appearance, aroma and texture), the formulations (GAD, PEA & SAB) were manipulated to determine their effects. The design was deemed appropriate for the study since it enabled the researcher to develop a complementary food, identify the chemical constituents of the complementary food and determine the functional characteristics of the complementary food. The design also aided the researcher to sensorily evaluate the acceptability of the complementary food.

The primary advantage of the design is the strength with which a causal relationship can be inferred. However, in looking at this advantage, it is important to distinguish between causal description and causal explanation (Shadish, Cook & Campbell, 2002). Experimental approach enables the researcher to affect the greatest degree of control. In an experiment, one is seeking an answer to a specific question. In order to obtain an unambiguous answer, it is necessary to institute control over irrelevant variables by either eliminating their influence or holding their influence constant.

Also in an experimental study one has the ability to manipulate precisely one or more variables of the experimenter's choosing. The experimental approach enables one to control precisely the manipulation of variables by specifying the exact conditions of the experiment. The results can then be interpreted unambiguously, because the research participants should be responding primarily to the variables introduced by the experimenter.

Population

A population is the general group from which the researcher wishes to obtain data to study (Frankel & Wallen, 2006). According to Amedahe (2004), the target group about which a researcher is interested in gaining information and drawing conclusions is what is known as the population. It is a group of individuals who have one or more characteristics in common that are of interest to the researcher.

In this study, the target population was all infants in the Cape Coast Metropolitan area. For the purpose of the study, the accessible population consisted of infants from six (6) to twenty four (24) months in the Cape Coast Metropolitan area**.**

Sample and Sampling Procedures

A sample denotes a small and representative proportion of the population. According to Amedahe (2000), sampling involves the process of selecting a portion of the population to represent the entire population. The researcher adopted the purposive sampling procedure to select fifty six (56) infants (with the aid of their mothers) from six (6) to twenty four (24) months old for the study. The sampling was done at the University of Cape Coast Hospital on babies who have been coming for post natal care on regular basis. The researcher requested for the attendance list of babies and using random sampling 100 babies were sampled. Out of hundred (100) babies who regularly attend post natal care, forty (40) were babies above the ages of of 24 months old. Hence they were not considered for the study since the researcher was testing the formulations on babies from six (6) to twenty four (24) months. On the day of the data collection four (4) mothers opted of the study, since they were given the option to participate or otherwise in the study and 4 of the panellists opted out on their own.

Data Collection Instruments

The instrument for the data collection was self developed and it was reviewed by an expert in sensory evaluation. The data for this study was collected with the developed instrument to elicite information on the acceptability or otherwise of the four formulations (GAD, PEA, KAN &

SAB). The instrument was in one section about the four formulations to be evaluated by the infants (panellists) (Refer to Appendix A).

Ethical Consideration

Ethical clearance was obtained from the Institutional Review Board (IRB) of University of Cape Coast for the purpose of granting the researcher the permission to carry out the research which bothers on health implications on the consumption of the complementary food (Refer to Appendix G for copy of ethical clearance letter). Consent forms of participation were either signed or thumb printed by the panellists. The consent form was in English and Fante language (Refer to Appendix I and J for details).

Pre test

Sensory evaluation questionnaires were pilot tested using 10 panellists (infants with their mothers) at the Amanful community. The internal reliability of the sensory evaluation questionnaire using the Cronbach's alpha coefficient was expected to be 0.80, which will indicate a high internal correlation among the items. The content validity in meeting the objectives of the study was established with the help of literature.

Materials and Methods

Source of Raw Materials

The *Apomuden* variety of orange fleshed sweet potato was purchased from Ministry of Food and Agriculture, Cape Coast office, and was used as the major ingredient for all the complementary food formulations. Other ingredients used were anchovies, which were bought from Elmina beach shore. Tomatoes (Bolga variety) and Onion (red onion variety) were bought from Kotokuraba market in Cape Coast. Commercial sweet potato complementary food (Cow and Gate brand) used as the control, was purchased from a supermarket in Cape Coast.

Development of Orange Fleshed Sweet Potato Flour

The flow chart for the production of sweet potato flour was adopted and modified. This method was described by Adeleke and Odedeji (2010).

Selected fresh tubers of orange fleshed sweet potato roots weighing 20 kg were washed thoroughly in water, peeled with a stainless steel knife, immersed in water to prevent discolouration and rewashed. The peeled roots were grated into chips using an ordinary grater. The chips were then spread thinly in a drying tray and dried in a hot air oven (Memmert model100-800) at 50 ^{0}C for 3 days. The dried chips were then milled into flour using an electric mill (Panasonic mixer grinder, MX-AC 2015). It was then sifted with a fine sieve and packed into zip lock bags and wrapped again in an opaque bag and impermeable package as suggested by Furuta *et al*. (1998); van Hal (2000) and stored in a freezer for later use.

Flow Chart for Production of Orange Fleshed Sweet potato Flour

a)Sweet potato flour production Adeleke and Odedeji, 2010

b) Modified method for sweet potato flour production.

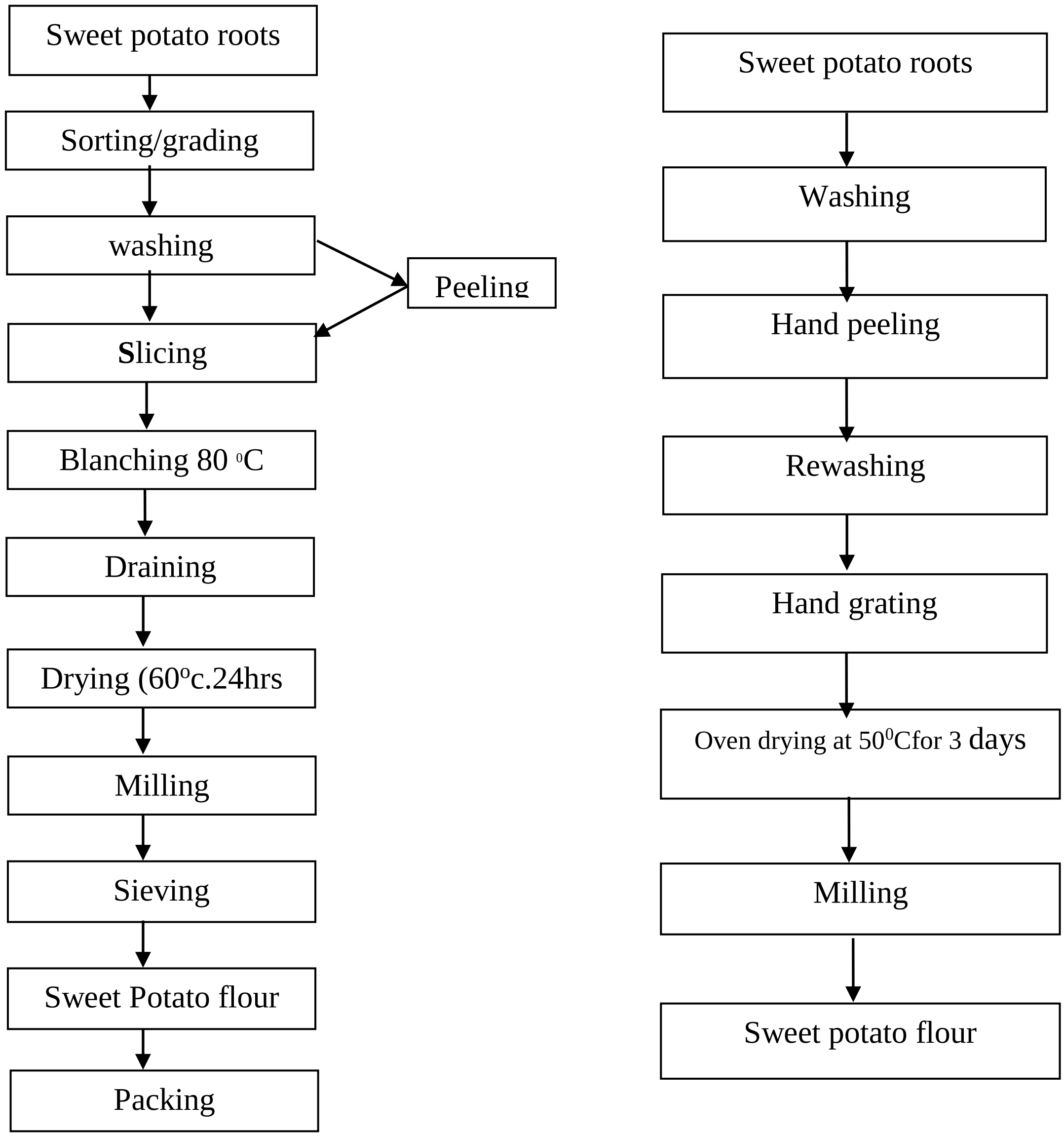

Figure 1: Flow Chart for Production of Orange Fleshed Sweet Potato Flour

Source: Adeleke & Odedeji, (2010)

Preparation of Anchovy Powder

Selected fresh anchovies weighing 3 kg were washed in water. The head and intestines were removed and rewashed. The prepared anchovies were spread in a drying tray and dried in a hot air oven (Memmert model100-800) at 50 ^{0}C for three (3) days. The dried anchovies were milled using an electric mill (Panasonic mixer grinder, MX-AC 2015). The anchovy powder was sifted with a fine sieve and packed into zip lock bags and stored in a cool dry place ready for formulation and analysis.

Flow Chart for Preparation of Anchovy Powder

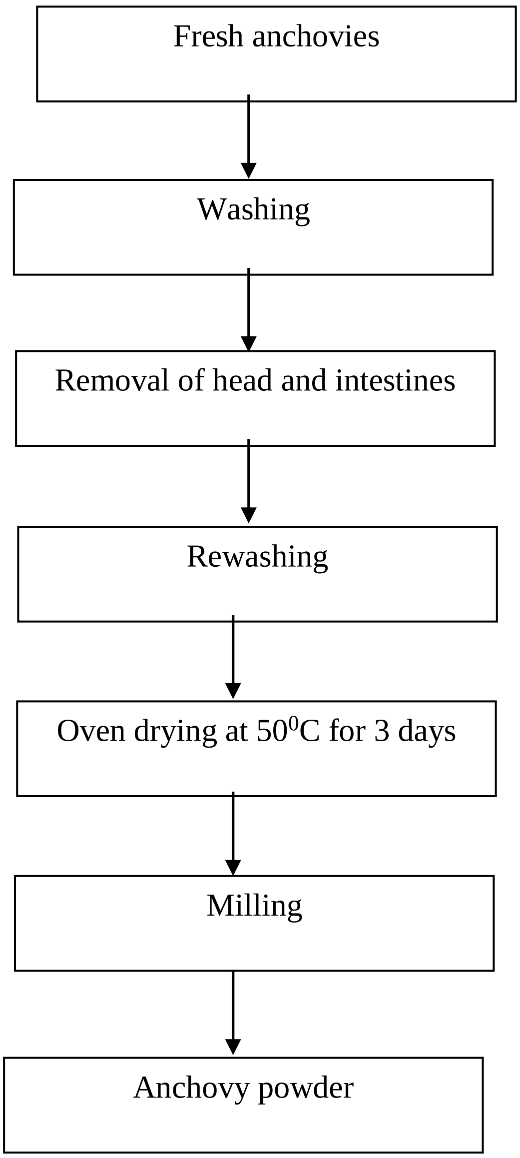

Figure 2: Flow Chart for Preparation of Anchovy Powder

Development of Onion Powder

Figure 3 shows the process flow diagram for the development of onion powder. The process is a self developed process. Selected fresh onions weighing 6 kg were peeled washed and chopped using the nicer dicer manual chopping machine. The chopped onion was spread thinly on a drying tray and dried in hot air oven (Memmert model100-800) at 50^0C for three (3) days. The dried onion was milled into powder using an electric mill (Panasonic mixer grinder, MX-AC 2015). It was then sifted with a fine sieve and packed into zip lock bags and stored in a freezer for later use.

Flow Chart for the Development of Onion Powder

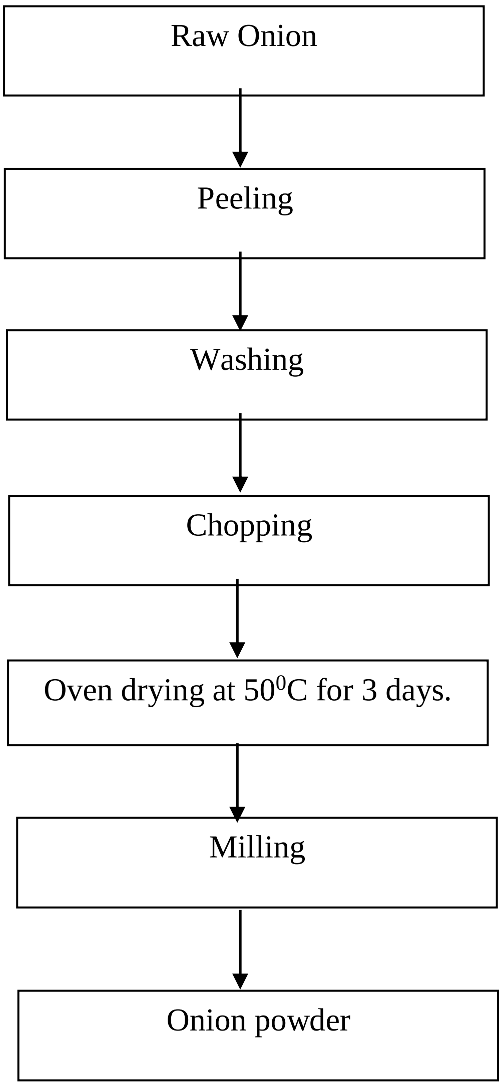

Figure 3: Flow Chart for Development of Onion Powder

Preparation of Tomato Powder

Figure 4 shows the process flow diagram for the development of tomato powder. The process was based on the modifications of the method described by Ashby, (2005) (as cited in Osae, 2014). Nine (9) kilograms of fresh and wholesome tomatoes (Bolga variety) were washed, blanched in boiling water for 3 minutes and then refreshened. The blanched tomatoes were then deskinned, deseeded and cut into quarters with a knife. The quarters of tomatoes were spread thinly on a drying tray and dried in a hot air oven (Memmert model100-800) at 50 ^{0}C for 3 days. The dried tomatoes were milled into powder using an electric mill (Panasonic mixer grinder, MX-AC 2015). It was then sifted with a fine sieve and packed into zip lock bag and put in the freezer for later use.

Flow Chart in the Preparation of Dried Tomato and Tomato Powder

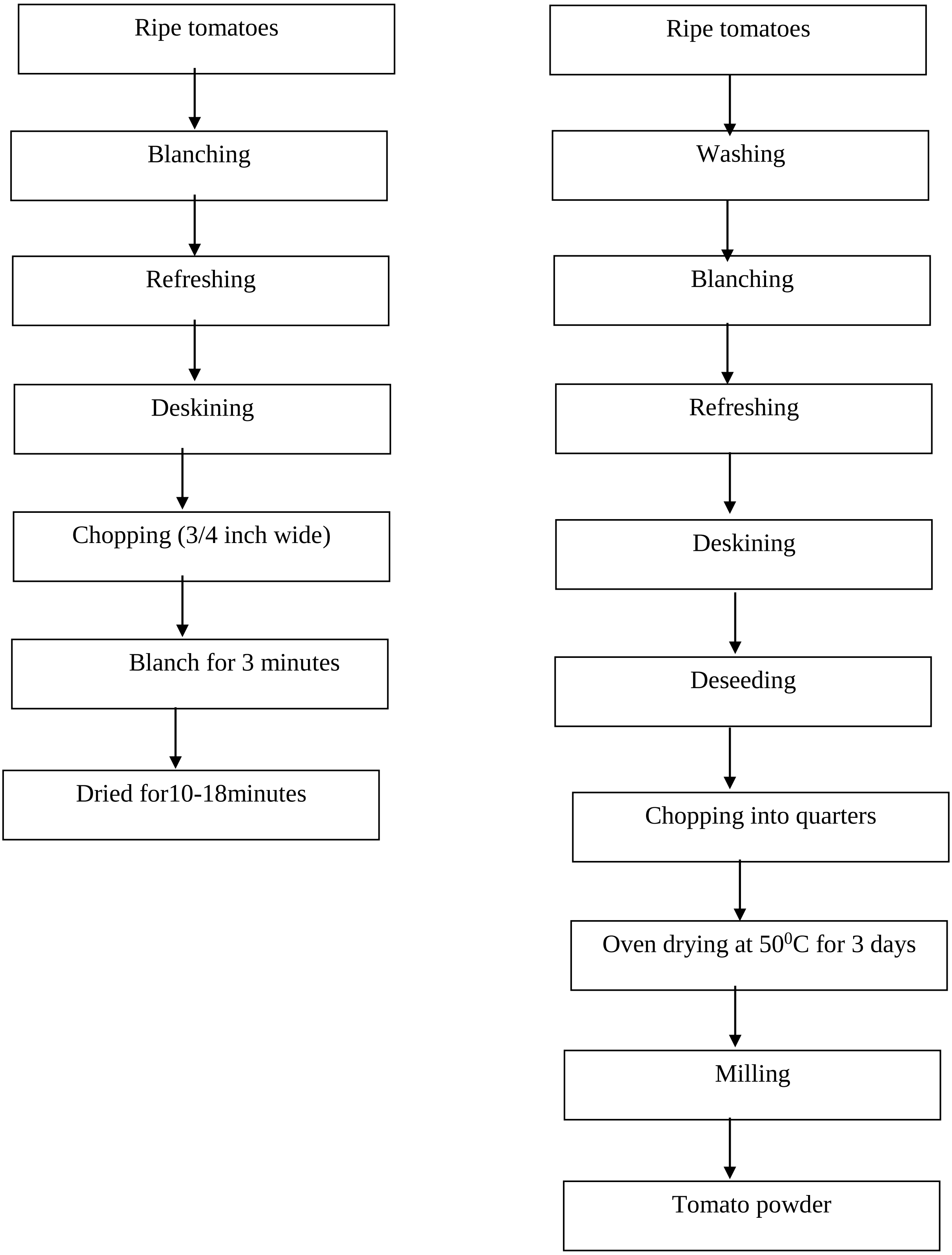

Figure 4: Flow Charts for Dried Tomatoes and Tomato Powder Preparation

Source: Ashby (2005) as cited in Osae, (2014).

Chemical Analysis of Samples and Formulated Formulas

Chemical constituents of samples and formulated formulas were determined according to the methods described by AOAC (2000). All these were done in triplicates. These analyses were conducted at the School of Agriculture laboratory of the University of Cape Coast.

Determination of Moisture

Ten (10g) grams of samples were weighed and transferred to a washed, dried and weighed crucible. The crucibles containing the sample were spread over the base of the Memmert oven (model100-800) to ensure equal distribution of heat. They were then kept in the thermostatically controlled oven at 105 ºC for twenty four (24 hrs) hours. After twenty four (24 hrs) hours the samples were removed, cooled in a desiccator and weighed. The moisture content was then calculated as the percentage water loss by the sample using the formula:

$$\% \text{ moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times \mathbf{100}$$

Where: W1= Weight of crucible

W2=Weight of crucible + fresh grated sample

W3 = Weight of crucible + Dry sample

Determination of Crude Protein Content

Crude protein present in food is calculated from nitrogen concentration of the food. The kjeldahl method was used in the determination of protein. The method can be divided into three steps: digestion, neutralization or distillation and titration.

Digestion

Five grams (5g) of the sample was weighed into a100 ml Kjeldahl flask 4.4 ml of the digestion reagent was added and the samples digested at 360^{o}C for two hours. A blank was prepared **(**Digestion of the digestion mixture without sample) were carried out in the same way. After the digestion, the digests were transferred into 50 ml volumetric flasks and made up to the volume.

Distillation

A steam distillation apparatus was set up. The distillation apparatus was flushed with distilled water for about twenty (20) minutes. After flushing out the apparatus, five (5) millilitres of boric acid indicator solution was poured into a 100 ml conical flask was placed under the condenser of the distillation apparatus with the tip of the condenser completely immersed in the boric acid solution. An aliquot of the sample digest was transferred to the reaction chamber through the trap funnel. Ten (10) ml of alkali mixture was added to commence distillation immediately and about 50 ml of the distillate was collected.

Titration

The distillate was titrated with 0.1N HCl solution until the solution changed from green to the initial colour of the indicator (wine red). Digestion blanks were treated the same way and subtracted from the sample titre value.The titre values obtained was used to calculate the nitrogen and hence the protein content.The conversion factor used was 6.25.

%Total Nitrogen (%N) =

$$\frac{(\text{Sample titre value} - \text{Blank titre value}) \times 0.1 \times 0.01401 \times 100}{\text{Sample weight} \times 10}$$

% Protein = %N x 6.25

Determination of Ash

Ash content of material represents inorganic residue left behind after burning of organic matter or the mineral content present in the sample. Ten grams (10 g) of sample was weighed and transferred into a weighed crucible and placed in a carbolite furnace (model AAF 1100) at 105 ºC for about an hour and then transferred to furnace at a temperature of 550 ºC overnight, the heating continued until all the carbon particles were burnt away. The ash in the crucible was removed from the furnace and placed in a dessicator, allowing it to cool, after which it was weighed. The ash content was then calculated using the formula below.

$$\% \text{ Ash} = \frac{W_3 - W1}{W2 - W1} \times \mathbf{100}$$

Where:

W1 = Weight of crucible,

W2= Weight of crucible + fresh grated sample,

W3=Weight of crucible + Ash

Determination of Crude Fat

The soxhlet extraction method was used for this study. About five grams (5g) of the sample was weighed into a 50×10mm soxhlet extraction thimble. This was transferred to a 50 ml capacity soxhlet extractor. A clean dry 250 ml round bottom flask was accurately weighed and then 150 ml of petroleum spirit was poured into the flask and connected to the soxhlet extractor and extraction was done for 6 hours using a heating mantle as a source of heating. After the 6 hours the flask was removed and placed in an oven at 60^{o}C for 2 hours. The round bottom flask was removed, cooled in a desiccator and weighed. The percentage fat/oil was calculated as followed.

$$\%Fat = \frac{W_2 - W_1}{W_3} \times \mathbf{100}$$

Where:

W1 = Weight of empty flask

W_2 = Weight of flask +fat

W_3 = Weight of samples taken

Determination of Crude Fibre

Crude fibre is the organic residue which remains after the food sample has been treated under standardized conditions with standard boiled acid and alkali solutions.Two grams (2g) of the sample was weighed into a boiling flask; 100 ml of the 1.25% sulphuric acid solution was added and boiled for 30mins. After the boiling, filtration was done in a numbered sintered glass crucible. The residue was transferred back into the boiling flask and 100 ml of the 1.25 % NaoH solution was added and boiled for 30 minutes. Filtration continued after the boiling and the residue washed with boiling water and methanol. The crucible was dried in an oven at 105 ^{o}C overnight and weighed. The crucible was placed in a furnace at 500^{o}C for about 3 hours. The crucible was slowly cooled to room temp in a desiccator and weighed. Crude fibre was expressed as weight loss in weight percent. The crude fibre content of the sample was then calculated and reported as percentage.

%Crude Fibre =

$$\frac{\text{Weight of sample before ashing - weight of sample after ashing}}{\text{Weight of sample}} \times \mathbf{100}$$

Determination of Carbohydrate

Five milligrams (5 g) of the sample was weighed into a 50 ml conical flask, 30 ml of distilled water was added and a glass bubble placed in neck to simmer gently on a hot plate for 2 hours. It was topped up to 30 ml periodically and allowed to cool slightly, then filtered through a No.44 Whitman paper into a 50 ml volumetric flask and dilute to volume when cool. The extract was prepared shortly before colour development. A blank was prepared by taking it through same procedure. Two (2) ml of each standard was pipette into a set of boiling tubes and 2ml of the extract and water blank was also pipetted into a boiling tubes. Standards and samples were treated the same way 10 ml of anthrone solution was added rapidly to mix and the tubes immersed in running tap water or ice bath. The tubes were placed in a beaker of boiling water in a dark fume cupboard and boiled for 10 minutes. The tubes were then placed in cold water and allowed to cool, preferably in the dark. The optical density was measured at 625nm or with a red filter using water as a reference. A calibration graph was prepared from the standards and used to obtain mg glucose in the sample aliquot. The blank determination was treated same way and subtraction done.

$$\text{Soluble carbohydrates (\%)} = \frac{\text{C (mg)} \times \text{extract volume (ml)}}{10 \times \text{aliquot (ml)} \times \text{sample wt (g)}}$$

Where C= carbohydrate concentration from the calibration graph

Determination of β-carotene of the Formulated Complementary foods

The ß-carotene content of the formulated complementary food was determined using the method described by Rodriguez-Amaya and Kimura (2004).

Three (3) g of freeze-dried and milled sample was weighed into a beaker and hydrate for 10 minutes with still water using the ratio 1:5; sample: water.

The hydrate sample was put in a mortar containing a small amount of Hyflosupercel, 30 ml of cold acetone was added and mixed with the help of the pestle and filter with suction through a sintered glass funnel, receiving the extract in a protected suction flask. The process was repeated until the residue was devoid of colour. Twenty mililiters (20 ml) of petroleum ether was put in a separation funnel after which acetone was added. Two hundred milliters (200 ml) of distilled water was added slowly along the wall of the funnel. The two phases were allowed to separate and the lower aqueous acetone phase discarded. Another portion of the acetone extract was added and the operation was repeated until all the extract was transferred to petroleumether, it was then wash about 5 times with water to remove residual acetone. The petroleum ether phase was collected into a 25ml volumetric flask by making solution pass through a small funnel containing anhydrous sodium sulphate to remove residual water. The carotenoid ethereal extract was read at 450 nm and the total carotenoid concerntration using the coefficient of absorption for ß-carotene.

$$X\,(\mu g) = \frac{A x Y(ml) x 10^6}{A^{1\%}_{1cm} x 100}$$

$$\frac{X\,(\mu g)}{g} = \frac{X\,(\mu g)}{\text{Weight of sample (g)}}$$

Where:

X = weight or concerntration of the carotenoid

Y = volume of the solution that gives an absorbance (A)

$A^{1\%}_{1cm}$ = absorption coefficient of β carotene in petroleum ether

Formulation of Complementary Food

The developed complementary foods were coded GAD, PEA and SAB as presented in Table 4. The proportion of the ingredients was based on ratios. The constituents were varied on ratio bases to determine the one with the best taste and aroma, the proportion of the constituents in terms of protein, fat, fibre, carbohydrate, moisture and ash present in the formulations and its effect in the formulations. An increase of a particular ingredient in the formulation may make it a significant choice for a child or his/her mother as this was a major factor considered in making the combinations. The mother of an infant may have greater influence when it comes to the choice of food formulations to give her child.

The ratio used in formulating GAD was (4:2:1:1). The ratio presented means that 100g of orange fleshed sweet potato flour, 50g of anchovy powder, 25g of tomato powder and 25g of onion powder were weighed and mixed together to form GAD. The PEA (5:1:1:1) formulation was made up of 125g of orange fleshed sweet potato flour, 25g of anchovy powder, 25g of tomato powder and 25g of onion powder. SAB (3:3:1:1) sample contained 75g of orange fleshed sweet potato flour, 75g of anchovy powder, 25g of tomato powder and 25g of onion powder.

Table 4: Compositions of Formulations

Ingredients	GAD (200g)	PEA (200g)	SAB (200g)
Sweet potato flour	100g	125g	75g
Anchovy powder	50g	25g	75g
Tomato powder	25g	25g	25g
Onion powder	25g	25g	25g
Ratio	**4:2:1:1**	**5:1:1:1**	**3:3:1:1**

Source: Field Data, (2017)

Determination of Functional Properties of the Flour Samples

Functional properties are those properties that determine the behaviour of nutrients in food during processing, storage and preparation since they have an effect on the general quality of foods as well as their acceptability.

Determination of Swelling Power

The method as described by Ukpabi and Ndimele (1990) was used in the determination of the swelling index. Three (3) grams of sample flour was weighed and poured into a previously weighed 50 ml capacity centrifuge tube. The samples were gently leveled and the volume recorded. Thirty (30) ml of distilled water was added to the sample. The cyclinder was swirled and allowed to stand for 60 minutes while the change in volume was recorded every 15 minutes. The ratio of the initial volume to the final volume gave the swelling index. The swelling index was calculated as follows:

$$\text{Swelling index} = \frac{\text{Change in volume of sample}}{\text{Original weight of sample}}$$

Determination of Solubility

Solubility index was determined according to the method described by Ukpabi and Ndimele (1990). Two and a half grams of sample was measured into a 50 ml centrifuge tube. Thirty (30ml) mililitres of water was added and vigorously mixed, the mixture was incubated in a water bath at 30°C for 30 min, and centrifuged at 2200 rpm for 15 min. The supernatant was collected in a preweighed petri dish and the residue was weighed after oven drying overnight at 105°C, in order to calculate the solubility. The solubility as calculated as follows:

$$\text{Solubility Index} = \frac{\text{Weight of soluble sample}}{\text{Weight of sample dry basis}} \times \mathbf{100}$$

Determination of Bulk Density

The bulk density (BD) of the sample was determined using the method described by Onwuka (2005). Five (5) grams of the sample flour was weighed into 25ml graduated measuring cylinder. The samples were packed by gently tapping the cylinder on the bench top 10 times from height of 5cm. The volume of the sample was recorded. The bulk density was calculated as;

$$\text{Bulk Density} = \frac{\text{Weight of the sample (g)}}{\text{Volume of the sample after tapping (ml)}}$$

Determination of Water Absorption Capacity

The method decribed by Adebowale, Sanni and Awonorin (2005) was adopted for the determination of water absorption capacity. Two (2) grams of the sample was weighed into a graduated centrifuge tube. Twenty (20) ml of distilled water was added and tube shaken for 5 minutes to obtain dispersion.The resulting dispersion was then centrifuged at 3500 rpm for 30 minutes. The volume of supernatant (free water) was measured while the sediment and centrifuge tube was weighed. The water absorption capacity of sample was then calculated per weight of initial dry sample.

$$\text{Water Absorption Capacity (\%)} = \frac{y - z}{x}$$

Where

x = Initial weight of (dried) sample taken

y =Initial volume of water added

z =Volume of supernatant collected

y – z = Volume of water retained by the sample after centrifugation

Sensory Evaluation

Preparation of Samples for Sensory Evaluation

Sweet potato baby food (control sample)

The ready to serve sweet potato baby food (Cow & Gate®) was heated in the microwave oven for about five minutes and poured into a labelled food warmer ready for sensory evaluation.

Preparation of Sweet Potato Complementary Food for Sensory Evaluation

Two hundred (200) grams (8 ounces) of the formulated complementary infant formula was stirred into 1000ml of boiling water. It was stirred with a wooden spoon until a smooth consistency was obtained. About three (3) grams of salt was added. The food samples were kept in labelled food warmers ready for the sensory evaluation.

Data Collection Procedure

An introductory letter was sought to introduce the investigator to the Institutional Review Board (IRB) of University of Cape Coast in relation to data collection for the study (Refer to Appendix G for details). Permission was also sought from the University of Cape Coast Hospital Management to use the hospital premises for the data collection (Refer to Appendix H for details).

The sensory analysis was conducted at University of Cape Coast Hospital (post natal section). The selected panellists (mothers with babies from ages of 6-24) were seated on individual tables and were trained on how to help their babies (panellists) taste the formulations; rinse their pellets before tasting the next formulations and evaluate the other attributes. Consent forms were given to the panellists and were signed or thumb printed. The complementary food samples were coded with the acronym; GAD, PEA, KAN & SAB to hide the true identity of the formulations. Each panellist was given a serving plate, 4 spoons and a cup of water to rinse their pallet in between tasting of the complementary foods samples and the coded complementary food samples in transparent cups. The complementary foods were evaluated in terms of appearance, taste, texture, aroma and overall acceptability using a 5 point hedonic scale (1=*Dislike very much*, 2=*Dislike moderately*, 3=*Neither like nor dislike*, 4=*Like moderately* and 5=*Like very much*) based on the reaction and facial expression of the babies.

The facial expression was used to evaluate the taste attribute only, the formulation using the smiley provided on the sensory evaluation questionnaire. For instance when a panellist frown the face could mean the formulation was not liked while a smiling face could mean the formulation is liked.The mothers of the panellists assisted them in scoring the other attributes (appearance, texture, aroma and overall acceptability). Sensory assistants were available to help panellists who could not read and write.

Statistical Analysis

In analysing the objectives, statistical software called Statistical Package for Social Scientist software for windows version 18 was used. The statistical tools descriptive mean and standard deviation were used to analyse objectives one to three. The data for objective one was further presented with bar chart to give the pictorial view of the data. One-way ANOVA was used from the Predictive analytical software for windows was to analyse objective four. The three hypotheses were also tested using independent samples t-test at 0.05 alpha value.

CHAPTER FOUR

RESULTS AND DISCUSSION

This study sought to formulate a complementary food from orange fleshed sweet potato for infants. This chapter presents the results obtained from the chemical analyses of the formulated food samples, functional properties, sensory evaluation of the complementary food and the discussion of findings.

Objective One: Development of Complementary Food for Infants

The complementary food was formulated from a combination of different proportions of orange fleshed sweet potato flour, anchovy, tomato and onion powder. The individual flour was analysed at the School of Agriculture Laboratory, University of Cape Coast. The proximate components (moisture, ash, protein, fat, fibre and carbohydrate) of the individual flours used in formulating the complementary food are presented in Figure 5.

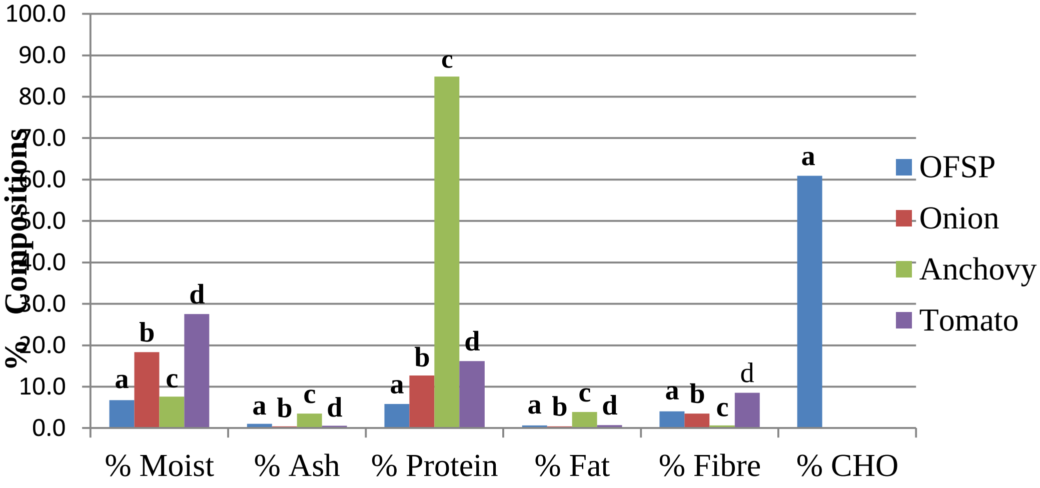

Figure 5: Proximate component of ingredients used
OFSP – Orange-fleshed sweet potato flour
a = OFSP, **b** = Onion, **c** = Anchovy & **d** = Tomato

Results from the study showed that anchovies used in the formulation had the highest protein value of 84.8% amongst the other ingredients. The proximate analysis in Figure 5 also revealed that protein was the highest nutrient identified in the anchovy powder. This was followed by carbohydrate, moisture, fibre, fat and ash respectively. There have been reports on the protein content of anchovies when different methods were used in processing. Bereket, Melakel Abdu, Habte-Michael *et al*. (2017) used solar tent to dry anchovies and determined the protein content. They found the protein content to be 79.32% but when they used an open sun rack they found the protein content to be slightly lower (75.32%). This difference could be attributed to the difference in the efficiency of drying methods used. However, tomato and onion powder when analysed had 16.2% and 12.7% of protein respectively. The protein content of the orange fleshed sweet potato flour (OFSP) was found to be rather low (5.9%) probably because it is a starchy root.

The OFSP flour had high (65%) carbohydrate content. This characteristic of orange fleshed sweet potato (OFSP) flour was expected because it is a starchy root. Since complementary foods are expected to be energy densed (Abeshu, Lelisa and Geleta 2016), this attribute makes orange fleshed sweet potato (OFSP) flour a suitable ingredient for developing complementary food. The carbohydrate percentage (65%) reported in this study was lower than that found by Laryea (2016) and Dansby and Bovell – Benjamin (2003) which were 83.29% and 90.6% respectively. Gichuhi, Kpomblekou and Bovell-Benjamin (2014) explain that the difference in carbohydrate content as cited by Laryea (2016) and Dansby and Bovell – Benjamin (2003) may be due to differences in variety of the sweet potato, stage of maturity, the method of cultivation, and soil conditions under which the sweet potatoes were planted.

Percentage moisture recorded were higher (27.5%) as shown in Figure 5 with respect to tomato powder. This was not surprising because tomato is a fleshy vegetable known to contain high water content. Onion powder had 18.35% moisture while anchovy powder had 7.6%. The least moisture content of 6.9% was found in orange fleshed sweet potato flour. The value obtained for orange fleshed sweet potato flour in this study was within the range reported by some researchers (Van Hal, 2000; Osundahunsi *et al*; 2003; Aina, Falade, Akingbala & Titus, 2009). These authors reported a moisture content range of 2.50 – 13.2%. Similarly, Dery (2012) observed that the Apomuden variety (the same variety used in this study) contained the highest moisture content among the six varieties of sweet potatoes studied. This confirms that the moisture content obtained in this study for orange fleshed sweet potato (OFSP) flour was reasonably good.

Results from the fibre analysis revealed that tomato powder had the highest fibre content of 8.5% and that of orange fleshed sweet potato flour was 4.1%, followed by onion powder (3.5%). The least amount of fibre 0.7% was found in the anchovy powder and was slightly lower than that reported by Edusei, Aseidu, Sakyi-Dawson and Owusu (2004). Opadotun, Adekeye, Ojukwu and Adewumi (2016) report of lower fibre content in tomatoes dried by sun and oven drying. The sun dried tomatoes recorded 0.21% whiles the oven dried 0.28%. The difference could be attributed to the difference in the methods and the variety of tomatoes used.

Ash content is considered very essential as it gives a measure of the mineral elements that can be obtained from the food sample (Shovon, Abida, Muhammad & Muhammad *et al*., 2013). In this study, ash content was quite low; however, the anchovy powder exhibited the highest percentage (3.5%) of ash. Bereket *et al.* (2017) found a higher ash percentage when anchovies were analysed compared to what was revealed in this study. In their investigation, the result showed that ash content was 9.9% in solar tent dried anchovy and 9.20% in the open sun rack dried anchovy. Although the orange fleshed sweet potato flour was prepared from a starchy root, it also had 1.1% of ash which was higher than what was recorded from the tomato and onion powders 0.6% and 0.4% respectively.

The fat content of the anchovy powder shown in Figure 5 was the highest (3.9%). This was followed by the tomato powder which had 0.7% and that of the orange fleshed sweet potato flour was (0.6%). The least amount of fat (0.4%) was found in the onion powder. The value was similar to that reported for the other varieties of onion bulbs from different origins (Shovon *et al*., 2013). According to Aina *et al*. (2009), sweet potato, like other roots and tubers is known to contain low fat which implies that the flour produced in this study could be stored for a longer period of time without going rancid as reported by Ogunlakin *et al*. (2012).

The proximate analysis showed that the ingredients used in formulating the complementary food contained moderate amount of nutrients. The protein, ash and fat content of the anchovy were good enough to serve as an excellent source of high biological protein needed for the growth in babies. Therefore, blending orange fleshed sweet potato flour as an energy food with tomato rich in moisture and fibre, and onion would make a nutritionally good complementary food suitable for weaning infants.

Objective Two: Assessing the Chemical Constituents of the Complementary Food

The chemical constituents (moisture, ash, protein, fat, fibre, and carbohydrate & β carotene) of the formulated complementary food are presented in Table 5.

Table 5: Chemical Constituents of the Three Complementary Food Samples

	Chemical Constituents of Formulations						
Sample	**%Moisture**	**%Ash**	**%Protein**	**%Fat**	**%Fibre**	**%CHO**	**β-Caroteneug/g**
SAB	12.62±0.08[a]	5.62±0.18[b]	44.04±0.8[a]	2.35±0.11[a]	4.02±0.04[a]	36.65±0.47[a]	90.21±.55 [a]
GAD	12.33±0.02[a]	5.68±0.08[b]	31.97±0.5[a]	1.99±0.14[a]	4.14±0.5[a]	35.54±1.08[a]	134.26±1.28 [a]
PEA	12.89±0.15[a]	5.58±0.13[b]	21.83±0.8[a]	1.24±0.01[a]	5.39±0.21[a]	49.22±1.39[a]	142.2.57 [a]
KAN (Control)	85.47±0.15 [a]	0.56±0.03 [a]	13.80±0.23 [a]	5.41±0.20 [a]	6.08±0.06 [a]	43.81±0.53 [a]	77.89±0.28 [a]

-Source: Field Data, (2017)

Values are averages of triplicate determinations-Data is represented as mean ± standard deviation

-Sample ratios are represented as (Orange-fleshed sweet potato: anchovy: onion: tomato)

-Values in same column with same superscripts are significantly different at 95% confidence level

The moisture content of flour usually determines its shelf life thus storability. From the moisture content analysis shown in Table 5, PEA had the highest percentage of moisture followed by SAB and GAD respectively. The moisture content of the complementary food increased with increased inclusion of OFSP flour. In PEA the amount of OFSP flour used was 125g.

The results indicate that GAD could be stored for the longest period compared to the two (2) other formulations of the complementary food. This is because it had the lowest moisture content. It could be noted that the moisture content recorded for all the three formulations (GAD, SAB, and PEA) were greater than the recommended moisture content in complementary food of 5% and 10% suggested by the Protein Advisory Group (PAG, 1971). Similarly, authors like Ojinnaka *et al*. (2013) record high moisture content of $11.55^{ab} \pm 0.20$ to $16.51 \pm 0.03\%$ in a soya bean cocoyam complementary foods they prepared. On the contrary, Mbaeyi-Nwaoha and Obetta, (2016) record a lower moisture content ranging from $3.39^{d} \pm 0.060$–$4.78^{a} \pm 0.090$ in their millet, pigeon pea and seedless breadfruit leaf powder blends. Although, the moisture content was higher in this study, it was below the 14.5% level recommended by AACC, (2000) which encourages microbial growth and could cause deterioration of the flour. According to Shahzadi *et al.* (2005), flour products with moisture content less than 13% are more stable from moisture-dependent deterioration. The high moisture content recorded in this study may be attributed to the variety of sweet potato used and the drying technique used. Dery (2012) also found Apomuden (the orange fleshed sweet potato variety used) to be high in moisture content thus difficult to process into flour.

With high ash content of the complementary food analysed, the products could be said to have high minerals content. These values varied among all the three (3) formulations (SAB, GAD & PEA). GAD had the highest percentage of ash followed by SAB and the least ash percentage was found in PEA. The high percentage of ash found in GAD was rather unexpected as the SAB formulation contained a higher proportion of anchovy powder compared to GAD. This could be attributed to the fact that the more the anchovy in a formulation the less ash it produces and also the opposite is the case in that the less the anchovy the less the higher ash it produces in the formulation.

The ash content observed in this study was higher than that reported by other authors Nandutu and Howell (2009), 3.2 ± 0.8 and 2.0 ± 0.0 for recipe A and B respectively and Ojinnaka *et al.* (2013) 0.23 ± 0.02 to $0.57\pm0.01\%$ for blends of soybean flour, ginger and modified cocoyam starch.

According to Whitney, Hamilton and Rolfes (1990), minerals play critical roles in the lives of infants and young children. They help in building strong teeth and bones, functioning of muscles and nerves, blood clotting, boosting of the body's immune system and promoting proper functioning of other organs of the body. The ash content in all the three (3) formulations (GAD, PEA & SAB) in this study had mineral contents that were above the recommended value by the World Health Organization and Food and Agriculture Organization of the United Nations(WHO/FAO) (2004) and PAG (1971) which was <5 g/100 g.

Protein is one of the most essential macronutrients required in complementary foods, and is necessary for rapid growth and development of an infant. The protein content of the formulated complementary food products (SAB, GAD & PEA) varied. Clearly, the protein content for SAB was more as compared with the other two formulations as shown in Table 5. A significant observation in this study was the high protein content of SAB especially being more than twice of PEA and that of GAD was 12.07% less. SAB contained the highest percentage of protein; however this percentage was expected as the formulation contained more anchovy powder compared with the other formulations (PEA & GAD).

The percentages of protein recorded in this study were higher than what was found in a previous study by Bonsi, Plahar, and Zabawa (2014), who found protein in the range of 12.1%-15% for their sweet potato based complementary food. It could be that Bonsi *et al* (2014), have different ratio proportions of the ingredients used are not the same as what the researcher used. Hence, it was assumed that their formulation is avariance to what was used in the current study. Nandutu and Howell (2009) also record a protein content of 20.4±0.1% and 28.0±0.4% in two complementary foods they developed from OFSP. The difference in protein percentages may be attributed to the ingredients used in the formulations of the complementary foods. According to the Protein Advisory Group (PAG, 1971), every complementary food should contain about 20% protein. Looking at the results in Table 5, all the 3 formulations (SAB, GAD & PEA) had protein percentages higher than the recommended.

In reference to Bonsi *et al*. (2014), protein content found in the complementary food was far below what was recorded in all the three (3) formulated samples (GAD, SAB & PEA) under consideration. This makes the developed complementary food in the present study high in protein. Protein is an essential nutrient needed for growth, development and repair of worn out tissues. In line with this, the formulated food could be a source of providing these essential nutrients to an infant who needs them to aid in his or her development. In a similar study by Nandutu and Howell (2009), the protein content detected was higher than only one (PEA) of the three (3) formulations.

According to the World Bank (2005), malnutrition is difficult to reverse after two years of age. Therefore, the period of introducing babies to complementary food is considered as a critical stage in their life (WHO, 2003). This is the period when malnutrition of all forms set in, which leads to stunting, wasting and underweight and kwashiorkor. Babies should therefore be introduced to complementary foods which are high in energy with protein as suggested by Abeshu *et al.* (2016). A study by Grantham-McGregor, Cheung, Cueto, Glewwe, Richter and Strupp (2007), show that malnutrition in early childhood impairs cognitive functioning which has an impact on the educational attainment of children later in life. This also results in reduced capacity for physical work.

PEA which had the highest proportion of OFSP flour was found to have the highest percentage of carbohydrate as expected. This was followed by SAB and GAD respectively. The carbohydrate content increased with increasing orange fleshed sweet potato flour in the formulation. This can also be attributed to the fact that, the OFSP is a tuber and a carbohydrate based food. This finding is in line with that of other studies by Onoja, Akubor, Gernar and Chinmma (2014) who recorded 30.10 ± 0.01^a-32.87 ± 0.01^a carbohydrate content in their sorghum, soya bean and plantain complementary foods. Ikese *et al.* (2016) also recorded 37.40±1.72% of carbohydrate in wheat and groundnut complementary food.

Carbohydrate plays a very important role in complementary foods since it is supposed to be energy dense so as to supply energy needed by infants to carry out their rigorous crawling activities and numerous biochemical reactions. Other studies by Nandutu and Howell (2009) report 66.0± 0.2, 58±1.4% and Ojinnaka *et al.* (2013) report higher carbohydrate percentages 78.55^{a} $\pm 0.12^{a}$ -$80.87^{a}$$\pm 0.50$ than the values recorded in this study. All the three (3) formulations of the complementary foods in this study had carbohydrate content lower than that recommended by WHO/FAO (2004) and PAG (1971) for complementaryfoods (≥65g/100g). Findings in this study shows that, increasing the OFSP flour content could improve the carbohydrate content of the formulated complementary food.

The figures (78.55^{a} $\pm 0.12^{a}$ -$80.87^{a}$$\pm 0.50$) recorded by Ojinnaka *et al* (2013) were far above the suggested figures prescribed by WHO/FAO (2004) and PAG (1971). Excessive intake of carbohydrate from complementary food could be converted into fat and stored in the body, which gradually leads to infant obesity which increases their risk to diseases later in life. Deficiency of carbohydrate in the body can cause the body to convert proteins and body fat to energy, thus leading to lessening of body tissues (Gordon, 1999).

In terms of fibre content, PEA had the highest value, followed by GAD and the least was found in SAB. The high content of fibre in PEA could be attributed to the amount of OFSP flour used in the formulation. This implies that the higher the amount of OFSP flour used in the formulation, the higher the fibre content. Two of the formulations (GAD & SAB) in this study met the recommendation of the WHO/FAO (2004) which suggest that the daily recommended allowance in complementary foods should be <5%. What could account for the high fibre content in the formulation may be attributed to variety, origin and geographical location of where the OFSP was obtained. Although the fibre content exceeded the maximum specified content by the WHO/ FAO standards, it may not affect the consumers since it is soluble and also the high fibre content would help in easy digestion especially in infants Huang, Tanudjaja and Lum (1999). Mullin, Rosa and Reynolds (1994) assert that approximately 25-50% of fibre in sweet potato is soluble. A similar trend was reported by Shiriki, Igyor, and Gernah (2015), when they observed a fibre percentage of $2.25^{d}\pm0.02$-$4.42^{a}\pm0.02$ in complementary food prepared from maize, soyabean and peanut fortified with moringa oleifera leaf powder. The low crude fibre content may encourage infants to eat more nutrient dense food that may contribute in meeting their daily energy need and other essential nutrient(s) requirements (Ijarotimi & Keshinro, 2013). Solomon (2005) detected a high percentage fibre in a complementary prepared food from cereals and legumes ranging from 9.07 ± 0.26-10.8 ± 0.35. Mbaeyi-Nwaoha and Obetta (2016) recorded higher fibre content of $4.76^{c}\pm0.135$-$11.51^{a}\pm0.230$ from millet, pigeon pea and seedless breadfruit leaf powder blends. Though crude fibre does not supply nutrients to the body, it adds bulk to food, thus facilitates bowel movements (peristalsis) and preventing lots of gastrointestinal diseases in human (Gordon, 1999). Increasing the intake of dietary fibre increases stool bulk, causes flatulence, and decreases appetite (Abeshu *et al.*, 2016). According to Rolfes, Pinna and Whitney (2008**),** high-fiber foods give satiation by filling the stomach and delaying the assimilation of nutrients, therefore low fibre foods may be more suitable for preparing complementary foods. Excessive dietary fiber in complementary foods may have undesirable effects such as lower caloric density and irritation of the gut mucosa (Asma, El Fadi l & El Tinay, 2006).

Fats are vital part of all living cells, and are crucial for maintaining good health. The fat composition of the formulated complementary food samples recorded low fat percentages, as shown in Table 6. However, the highest percentage of fat was found in SAB which contained higher proportion of anchovy powder in its formulation.This was followed by GAD with PEA having the lowest percentage of fat. The results showed that the fat content increased with increasing quantities of the anchovy powder added to the formulation.

The fat percentages recorded by other studies were 4.8%-6.4% (Bonsi *et al.,* 2014), and 2.0±0.1-3.4±0.5 (Nandutu and Howell, 2009). The fat content in these 2 reports were higher than that of the present study. What may account for the low fat content in the current formulation may be attributed to the presence of the anchovy which produces protein hence it may have reduced the fat content in the present formulation. The present study found a fat content less than the daily recommended fat content for complementary foods, which ranges between 10% and 25% (WHO/ FAO 2004).

According to Mitchell (2011), fats enhance the taste, texture and smell of many foods, making them more appetising. Solomon (2005) recorded rather very high percentages 15.6±0.2-38.1±0.57 of fat in a complementary food she prepared. It is worth noting that the amount of fat found in any formulated food sample can affect its shelf life. This may be because high fat content foods undergo oxidative deterioration which leads to rancidification thereby making it more prone to spoilage than one with a lower fat content.

In addition, fats play a very important role in our bodies. Fats provide a more readily source of energy used in basal metabolism and stored fat can be converted into energy in times of need. Fats supply the fatty acids necessary for many body chemical activities such as supplying linoleic acid, an essential fatty acid needed for proper growth in children; it also prevents excessive skin dryness and flaking.

Fats make eating more delightful as it improves foods flavour, aroma and texture, as well as satiety because they are slow to digest. Fats supply essential fatty acids and aids in the absorption of fat soluble vitamins such as A, D, E and K (Pan American Health Organization (PAHO) and World Health Organization (WHO), 2001). The decrease in fat content could be an advantage to health as well as extending product shelf life as reported by Saskia and Martin (2008). Higher fat content is a nutritional advantage because it can increase the energy content of food (Lohia & Udipi, 2015). However, excessive fat in diet may increase micronutrient malnutrition in infants (PAHO/WHO, 2002). Dietz and Robinson (2005) also stipulate that excessive fat intake predisposes infants to childhood obesity and subsequently cardiovascular diseases.

The Beta (β) carotene content of the formulated complementary food samples was highest in PEA followed by GAD and SAB respectively. The higher content of β carotene in PEA formulation may be attributed to the higher amount of OFSP flour added to the formulation because the flour contains the β carotene. It can be deduced from the formulations that the higher the inclusion of OFSP flour, the higher the β carotene content of the formulated samples.

Beta (β) carotene is converted to vitamin A as and when needed (Mitchell, 2011). It plays an important role in the life of infants. Vitamin A is needed in minute amounts for normal functioning of the visual system, boosting of the immune system and supporting growth and development (Tariku *et al*., 2016).

The β carotene content obtained in this study was higher than that reported by Laryea (2016) in a sweet potato based complementary food he prepared and Bonsi *et al*. (2014) in a study to enhance Ghanaian complementary foods. The different values of β carotene reported for the complementary foods may be attributed to the variety of OFSP used in the various studies. Bonsi *et al.* (2014) used Beauregard variety, Laryea (2016) used Bohye and in the present study Apomuden variety was used.

According to Koletzko, Cooper, Makrides, Garza, Uauy and Wang (2008) the suggested daily allowance of vitamin A for infants between 6 months to 3 years is between 350 and 400 µg in a day. All the three (3) formulated (GAD, SAB & PEA) complementary food samples contained appreciable amount of β carotene but were below the range suggested for daily allowance of vitamin A for infants, hence they are likely to help reduce the menace of vitamin A deficiency among infants.

Table 5 also shows the chemical composition of the formulated samples (GAD, SAB & PEA) and that of the sweet potato complementary food (KAN) which was used as the Control. The results show that in all ash, protein and β carotene contents in the formulated samples (5.58%-5.68%, 21.83%-44.04% & 90.21%-142.2% respectively) were higher than their corresponding values in KAN (Control) (0.56%, 13.80 % & 77.89% respectively).

KAN (Control) had higher values in terms of moisture, fat, fibre and carbohydrates (13.47%5.41%,6.08% & 43.81% respectively) compared to the formulated samples (GAD, SAB & PEA) (12.33%-12.89%, 1.24%-2.35%, 4.02%-5.39% & 35.54%-49.22%). The carbohydrate content of the formulated samples (GAD, SAB & PEA) ranged from 35.54%-49.22% while the KAN (Control) had 43.81 which was within the values of the formulated samples range. It was observed that the carbohydrate content in the three formulations and the Control (KAN) were far below the recommended level for infant food as recommended by PAG (1971) to be 65%.

The results further reveal that the ash contents of the formulated samples were higher and could be attributed to the high amount of anchovy used in the formulations. The formulated samples (GAD, SAB & PEA) were richer in minerals than the KAN (Control) food in view of higher levels of ash present in the samples. It was also observed that, because high amounts of anchovy was used in the formulated samples (GAD, SAB & PEA) the protein content of the formulated samples far exceeded that of KAN (Control) compared to the recommended levels of protein that ought to be present in infant food which is 20% PAG (1971).

However, the formulated samples (GAD, SAB & PEA) may enhance tissue repair and body building if taken by infants, one of the functions of protein in diet than the KAN (Control) would do since its protein level was very low and thus would contribute less to body building and repair of worn out tissues. β carotene contents in all the formulations (GAD, SAB & PEA) were higher and this could be attributed to the variety of Orange Fleshed Sweet Potato (OFSP) which has been specially bred for its vitamin A. According to Tariku *et al*., (2016) Vitamin A is needed for normal functioning of the visual system, boosting of the immune system and support of growth and development. The high presence of β carotene in the present formulation would help infants' immune systems develop and help fight diseases that usually face babies. It is expected that continuous consumption of any of the formulations may guarantee healthy growth among infants.

A high fat content in a complementary food provides more energy for infants. Some amount of fat is important in the diets of infants and young children because it provides essential fatty acids, facilitates absorption of fat soluble vitamins, and enhances dietary energy density and sensory qualities (Pan American Health Organization & World Health Organization, 2004). Studies have shown that when fats exceed the desirable level in products, it tends to affect their stability, since the unsaturated fatty acids are vulnerable to oxidative rancidity that often shorten a products shelf life (Lohia & Udipi, 2015). The high fibre content in KAN may be attributed to the inclusion of sweet potato, peas and broccoli. However, it may not necessarily affect infants probably because it is soluble and would also help in promoting digestion especially in infants (Huang, Tanudjaja & Lum, 1999).

Objective Three: Determining the Functional Characteristics of the Complementary Food

The results of the functional characteristics of the complementary food samples are shown in Table 6.

Table 6: Functional Characteristics of Complementary Food Samples

Samples	Bulk Density (g/ml)	Swelling Power (g/g)	Solubility Index (%)	WAC (%)
GAD	0.79±.00	8.01±.11	39.52±.35	330.97±.26
PEA	0.78±.00	10.20±.31	37.13±.48	341.86±.64
SAB	0.77±.00	9.04±.35	40.50±.14	308.98±.58

Source: Field Data, (2017)
-Values are averages of triplicate determinations
-Data is represented as mean ± standard deviation
- The mean difference is significant at the 0.05 level.
-WAC-Water Absorption Capacity

Bulk density is an indication of porosity of a product, which influences package design. It also assesses heaviness of flour (Olaitan, Eke & Uja, 2014). It is affected by moisture content and particle size of the flour (Onimawo & Egbekun, 1998).

Results from Table 6, show that SAB had the least value of bulk density amongst the formulated samples, while GAD had the highest value of bulk density. The values recorded in this study were approximately close to that reported by Laryea (2016), but higher than that reported by Mbaeyi-Nwaoho and Obetta (2016) and lower than that recorded by (Olaitan *et al.*, 2014). Okorie *et al.* (2011) reports that bulk density depends on the particle size of the commodites used, thus the use of smaller particle size food items are associated with lower bulk density, and vice versa.

Akubor *et al.* (2013) report that lower bulk densities are considered best for complementary food as foods prepared from low density food items are easily digested by infants' while retaining the nutrients. High bulk density reduces caloric and nutrient intake per feed of a child which can result in growth faltering (Olaitan *et al.*, 2014). Looking at the results in Table 6, all the three (3) formulations (GAD, SAB & PEA) had lower bulk densities hence suitable to be used as complementary foods.

Swelling power was observed to be low amongst the formulated complementary food samples. A higher value was noted in sample PEA which had 125g of OFSP flour and 25g of anchovy, onion and tomato powder. GAD had 100g OFSP flour, 50g of anchovy powder and 25g of onion and the tomato powder and had the least swelling power. The results from Table 6 show that the samples could swell up to ten (10) times their original size and weight.

Kinsella (1976) and Ayo-Omogie and Ogunsakin (2013) both report that swelling causes changes in hydrodynamic proteins of food, thus impacting characteristics such as body, thickening and increase in viscosity to food. It has also been asserted that a lower swelling capacity of complementary foods is advantageous in feeding infants as it increases the nutrient density of the food, thereby enabling the child to consume more in order to meet his/her nutrient requirement (Afam-Anene & Ahiarakwem, 2014). This thus implies that among the formulated complementary foods, PEA with the highest swelling power may produce a thick viscous porridge compared to GAD and SAB.

The high swelling power of PEA could probably be due to the high OFSP flour content. The swelling power values recorded in the present study were higher than that reported by Ojinnaka *et al.* (2013) and Laryea (2016). However, researchers like Fasuan *et al* (2017) and Ikese *et al.* (2016) reported high swelling power values than that reported in this study.

Complementary foods with high swelling power are not desired much because they may absorb more water, resulting in a low nutrient densed food. Hence the swelling power reported in this study indicated that all the three (3) formulations (GAD, SAB & PEA) had low swelling power which makes them suitable for use as complementary foods.

Table 6 shows that SAB had the highest solubility index followed by GAD and PEA. Adepeju *et al.* (2014) highlighted that solubility is an index of protein functionality such as denaturation and its potential application. Therefore the higher the solubility, the higher the functionality of the protein in the food. It can be deduced from the results in Table 6 that, the solubility indices of the formulations (GAD, SAB & PEA) were higher when the proportion of anchovy powder added was higher. The values of solubility in this study were expected as the formulations contained higher content of protein.The solubility indices in the present study were higher than that reported by Adepeju *et al.* (2014) and Laryea (2016).

Water absorption capacity is an indication of the amount of water available in food for gelatinization (Ghasemzadeh & Ghavidel, 2011). According to them, lower absorption capacity is desirable for making thinner porridges. The water absorption capacity values varied amongst the three (3) formulations (GAD, SAB & PEA). SAB recorded the least water absorption capacity value while PEA exhibited the highest. The water absorption capacity values increased as the quantity of OFSP flour increased

The water absorption capacity of the formulated complementary food samples was higher than that reported by Laryea (2016), Onoja *et al* (2014) and Adepeju *et al.* (2014). However, Ghasemzadeh and Ghavidel (2011) recorded higher values of water absorption in a study titled "Processing and assessment of quantity characteristics of cereal-legumes composite weaning foods". The difference in values reported could be due to the different ingredients and varieties used. High water absorption capacity is unfavourable in complementary feeding as it limits the assimilation of nutrients (Afam-Anene & Ahiarakwem, 2014).

Therefore out of the three (3) formulated complementary foods, SAB had the least water absorption capacity and may provide a more nutrient densed food.

Objective Four: Sensory Evaluation of the Complementary Food Acceptability

The sensory characteristics of the complementary food samples are shown in Table 7. Samples were scored in terms of appearance, taste, texture, aroma and overall acceptability using the five -point hedonic scale. The sensory analysis questionnaire was responded by 56 panelists at the University of Cape Coast Hospital during their routine post natal visit.

Table 7: Sensory Result of Complementary Food Samples

	Parameters				
Sample	**Appearance**	**Taste**	**Texture**	**Aroma**	**Overall acceptability**
KAN	$4.36^a \pm 1.21$	$3.57^a \pm 1.36$	$3.79^a \pm 1.29$	$3.66^a \pm 1.29$	$4.00^a \pm 1.19$
GAD	$3.39^a \pm 1.06$	$3.21^a \pm 1.45$	$3.71^a \pm 1.17$	$3.66^a \pm 1.07$	$3.66^a \pm 1.28$
SAB	$3.25^a \pm 1.03$	$3.29^a \pm 1.41$	$3.75^a \pm 0.96$	$3.45^a \pm 1.11$	$3.52^a \pm 1.08$
PEA	$3.55^a \pm 1.10$	$3.41^a \pm 1.57$	$4.14^a \pm 4.12$	$3.54^a \pm 1.21$	$3.64^a \pm 1.17$

Source: Field Data, (2017)
*N=56 *Mean value in column of the same superscript are not statistically significant at $p<0.05$

The overall acceptability mean score indicated that KAN was the most accepted sample as shown in Table 7. Appearance is an important characteristic considered when selecting and accepting food. The appearance score for the samples showed that KAN (control) had the highest score, followed by the PEA, GAD and SAB. Apart from KAN having a higher mean score PEA's score was almost closer to it than the other two samples in terms of their appearance as shown in the results. In reference to the appearance, the difference between KAN and PEA in terms of their mean score was 0.81 meaning that there was no significant difference at ($p<0.05$) for appearance of the samples.

The taste for KAN (control) was rated highest as compared to the rest of the samples. However, GAD had the lowest rating. The results for the taste anaylsis of the samples as shown in Table 7 showed that the difference between KAN and PEA's mean score was 0.16. This implies that there was no much difference in the taste of KAN and PEA therefore there was no significant difference at ($p<0.05$) in the taste of these products.

The mean score for texture was high for PEA, followed by KAN (control) with GAD having the lowest mean score. The difference in value between PEA and KAN was 0.35 hence there was no significant difference at ($p<0.05$) between PEA and KAN.

The values for the aroma rating of the samples by the panellists were in the range of 3.45 and 3.66. KAN which was the control and GAD one of the formulated samples had the highest aroma rating as shown in Table 7 while SAB had the least aroma rating. The value difference between GAD, KAN and PEA was 0.12. There was no much difference between the three samples which implies that there was no significant difference ($p<0.05$) among the samples in terms of aroma.

Score for appearance of the complementary food samples increased with an increase in the concentration of orange fleshed sweet potato flour. The different ratios used in formulating the food samples contributed much to the different appearance and colour of the samples. The panellists reported that they preferred colourful foods so they knew that babies are easily attracted to bright colours, so it was not surprising that panelists reported that. This is in line with a statement that colour and appearance are the initital quality features that attract people to a food product (Spence, 2015). According to Singh-Ackbarali and Maharaj (2014), colour and appearance are indices of the inherent good quality of foods associated with the acceptability. In reference to the appearance two of the panellists liked the colour of KAN very much.

KAN was rated the highest in terms of taste, however, there was a marginal value difference between KAN and PEA. The taste score for PEA may be attributed to the higher concentration of OFSP flour and lower concentration of anchovy powder in the formulation. Anchovy fish is often known to be associated with strong smell and unique taste. Bazaz *et al.* (2016) reported that taste is an important attribute in sensory evaluation of food. A product may be appealing to the eye and have high energy density but may not taste and smell well, such a product is likely to be rejected by consumers.

PEA product rated closest to KAN. The higher OFSP flour concentration in the formulation gave it a sweeter taste and reduced the strong and pungent smell and taste of the anchovy fish powder. Although KAN had the best rating for taste. Two of the panellists each liked the taste of all the formulated food samples except the control KAN. Four of the panellists liked KAN a lot whiles another 10 scored KAN high for taste.

Scoring PEA highest for texture may be attributed to the addition of increased orange fleshed sweet potato flour to the formulation of the sample compared to the other samples. Although PEA had the highest score for texture, some of the panellists complained about the coarse nature of the formulated samples of which PEA was one. This coarseness may be attributed to the particle sizes of the flour.

Texture and mouth feel are connected, however the mouth feel is considered as a very important attribute in complementary foods, because it determines the amount of food an infant would consume since they can only swallow smooth porridge foods and not coarse ones (Ojinnaka *et al.*, 2013).

In terms of aroma ratings, both KAN and GAD had the same mean scores. An increase of 3 in the aroma ratings of GAD may be due to the proportion of anchovy powder (50g) to OFSP flour (100g) in the formulation. This may have produced a mild aroma which may have influenced the panellists to like it. The least score recorded for SAB in terms of aroma may be attributed to increased quantity of anchovy powder in the formulation. SAB contained equal proportions of anchovy powder and OFSP flour, the aroma of the anchovy powder may have been so strong in the formulation which may have affected its aroma rating. Aroma is an integral part of taste in accepting food before it is put in the mouth (Bazaz *et al.,* 2016). It is therefore an important parameter to consider when evaluating the acceptability of food samples. Although, SAB had the least score for aroma, one of the panellists liked its aroma but two others rated the aroma of SAB to be poor.

The result as shown in Table 7 indicate that the overall acceptability score by the panellists was more for KAN, followed by GAD, and then PEA. However, SAB had the least overall acceptability score per the results. KAN was accepted based on the attributes presented (appearance, taste, texture and aroma) on the evaluation form. The panellists therefore, chose it to be the best among the other samples. Probably the appearance of KAN was attractive enough, as babies by nature are attracted to bright colours and the same arguement can be made for KAN. Looking at the mean score for the four samples as shown in Table 7, KAN had the highest mean score.

The tongue is the sense organ used in determining the taste of food. The taste is detected by taste buds which are on the tip of the tongue. In tasting the food samples, the panellists were provided with water to rinse out their pallet after each sample in order to remove all traces of the previous foods so as to prevent any form of bias. Looking at the taste mean value for KAN, it clearly showed that KAN had a higher mean value as compared to the other samples.

Although, the samples were presented randomly to the panellists, it could not be argued KAN was probably placed at an advantageous position (either first or last). So this may imply that panellist's choice of KAN as the best product was not influenced by its position during the sensory evaluation.

Hypotheses

1. H_0: There is no significant difference between the developed complementary food (GAD) from OFSP flour and the commercial manufactured (KAN) sweet potato baby food in terms of sensory qualities.

In testing hypothesis1, the results from the panellists are presented in Table 8.

Table 8: Result of Independent Sample t-Test of GAD and KAN Acceptability

Sample	N	Mean	Std. Dev.	t-value	Df	Sig (2-tailed)
GAD	56	3.7321	1.22832	-1.362	110	0.176
KAN	56	4.0357	1.12758			

Source: Field Data, (2017)

Table 8 presents the independent sample t-test for GAD and KAN in terms of acceptability by the panellists. The mean score of KAN was a little higher than that of GAD with a margin of 0.3, t-value of -1.362 which gave significance (2 tailed) of 0.176. The significant value being higher than the α-value of 0.05 suggest that the null hypothesis is accepted on the basis that the p-value obtained was more than α-value of 0.05. This implies that there is no statistical significant difference between the developed complementary food (GAD) from OFSP flour and the commercial manufactured (KAN) (cow and gate brand).

H_0: There is no statistical significant difference between the developed complementary food (SAB) from OFSP flour and the commercial manufactured (KAN) sweet potato baby food in terms of sensory qualities.

In testing hypothesis 2, the results from the panellists are presented in Table 9.

Table 9: Result of Independent Sample t-Test of SAB and KAN Acceptability

Sample	N	Mean	Std. Dev.	t-value	Df	Sig (2-tailed)
SAB	56	3.6250	1.01914			
				-2.022	110	0.046
KAN	56	4.0357	1.12758			

Source: Field Data, (2017)

Table 9 shows the independent sample t-test for SAB and KAN in terms of acceptability by the panelists, the mean score of KAN was a little higher than that of SAB with a margin of 0.41, t-value of -2.022 given significance (2 tailed) of 0.046 which is higher than the α-value of (0.05). In view of the significant (2 tailed) being lower, the null hypothesis was thus accepted on the basis that the p-value of 0.046 is equivalent to the α-value of 0.05. This implies that there is no statistical significant difference between the developed complementary food (SAB) from OFSP flour and the commercial manufactured (KAN) (cow and gate brand).

4. H_0: There is no statistical significant difference between the developed complementary food (PEA) from OFSP flour and the commercial manufactured (KAN) sweet potato baby food in terms of sensory qualities.

In testing hypothesis 3 the results from the panellists are presented in Table 10.

Table 10: Result of Independent Sample t-Test of PEA and KAN Acceptability

Sample	N	Mean	Std. Dev.	t-value	Df	Sig (2-tailed)
PEA	56	3.7143	1.09069	1.533	110	0.128
KAN	56	4.0357	1.12758			

Source: Field Data, (2017)

Table 10 shows the independent sample t-test of PEA and KAN in terms of acceptability by the panellists, the mean score of KAN was a little higher than that of SAB with a margin of 0.32, t-value of 1.533 given significance (2 tailed) of 0.128 which is higher than the α-value of (0.05). In view of the significant (2 tailed) being higher the null hypothesis was accepted on the basis that the p-value of 0.128 was more than α-value of 0.05. This implies that there was no statistical significant difference between the developed complementary food (PEA) from OFSP flour and the commercial manufactured (KAN) (cow and gate brand).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview of the Study

The summary, conclusions and recommendations of the study have been presented in this chapter. Suggestions for further studies have also been presented. The purpose of the study was to develop or formulate a complementary food from vitamin A rich orange fleshed sweet potato.

The developed complementary food could help address vitamin A deficiency in infants. Sensory evaluation was done to determine the acceptability of the complementary food in terms of appearance, taste, texture, aroma, and overall acceptability. Hypotheses were formulated to test whether there were any significant differences that existed between the formulated complementary food (PEA, GAD & SAB) and KAN (control)**.** SPSS version 20 for Windows was used to analyse data. Frequency, percentage, means, standard deviation, independent t-test were the tools used in the data analysis.

Key Findings

1. A complementary food was prepared from orange fleshed sweet potatoes, anchovies, onion and tomatoes. Anchovies had the higher protein, fat and ash content therefore considered to be important in body building and a source of calcium and zinc whilst orange fleshed sweet potatoes had the highest carbohydrates contents and perceived to be a source of energy.

2. The chemical anaylsis conducted found that the moisture content of the formulated complementary food samples was higher in PEA while GAD had the least moisture content. GAD recorded higher ash content while PEA recorded the least. The protein content of the samples was rather high; the difference between the highest (SAB) and the least (PEA) was 22.21%. The fat content from 1.24% to 2.35%. The fibre content was low in SAB while PEA recorded the highest content. The carbohydrate content was low in all the three formulations (PEA, GAD & SAB) and β carotene content ranged from 90.21 µg to 142.2 µg.
3. Bulk densities of the formulated complementary foods ranged from 0.77 to 0.79g/ml, swelling power ranged from 8.01 to 10.20, solubility from 37.13 to 40.50% and water absorption capacity ranged from 308.98% to 341.86%.
4. The most preferred complementary food was KAN which was the control followed by GAD which had 100g of orange fleshed sweet potatoe flour, 50g anchovies powder and 25g of onion and tomotoe powder. This preferred formulated complementary sample had the highest amount of β carotene being 134.26 µg.

Conclusions

The formulated complementary food samples can be used as a substitute for other locally available foods for infants. The new products can be used as a substitute for KAN (control) which is a foreign product. The ingredients for the production of the new formulations (PEA, SAB & GAD) were locally acquired and cheap hence can be affordable. The new formulations (PEA, SAB & GAD) would help fight the persistent vitamin A deficiency among infants in Ghana. The reason being that the Apomuden is rich in β carotene which is a precursor of vitamin A. Mothers could take advantage of the new formulations when finally produced in commercially quantities to supplement the local foods for infants.

The methods employed in this study can be adopted at household and community levels to produce nutrient densed complementary foods to help reduce the menance of vitamin A deficiency among infants in Ghana.

Recommendations

Based on the findings of this study, the following recommendations were made.

1. There is the need to conduct studies on microbial count for the most preferred formulated complementary food.
2. The shelf life of the most preferred formulated complementary food could be studied.
3. There is the need to employ different drying methods in drying the food commodities used in the formulations.
4. A cost evaluation for the sweet potato based complementary food should be conducted in comparison to the cow and gate products.

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APPENDICES

APPENDIX A

SENSORY EVALUATION QUESTIONNAIRE

Sensory Evaluation of Orange fleshed Sweet Potato complementary Food

Date ………..   No………….

Please examine, give a little to your baby to taste and score each based on the facial expression of your baby. Indicate how much they like or dislike each sample based on appearance, taste, texture, aroma and overall acceptability using the scale below. Put the appropriate number against each attribute.


1-***Dislike very much***


2-*Dislike moderately*


3-*Neither like nor dislike*


4-*Like moderately*


5-*Likevery much*

Please give the child water before and after tasting each sample.

Coded Samples	**Appearance**	**Taste**	**Texture**	**Aroma**	**Overall Acceptability**
GAD					
SAB					
KAN					
PEA					

Any comments……………………………………………………………

Thank you for participating

APPENDIX B

CONSTITUENTS IN THE FORMULATIONS

		N	Mean	Std. Deviation	Std. Error
%Moisture	SAB	3	12.61693	.079584	.045948
	GAD	3	12.32637	.019873	.011474
	PEA	3	12.89770	.146544	.084607
	Total	9	12.61367	.261268	.087089
%Ash	SAB	3	5.62113	.180018	.103933
	GAD	3	5.68823	.081913	.047292
	PEA	3	5.58473	.125187	.072277
	Total	9	5.63137	.125557	.041852
%Protein	SAB	3	44.04380	.815375	.470757
	GAD	3	31.96960	.510759	.294887
	PEA	3	21.83063	.083908	.048444
	Total	9	32.61468	9.642842	3.214281
%Fat and Oil	SAB	3	2.35017	.113197	.065355
	GAD	3	1.98720	.014010	.008088
	PEA	3	1.24200	.005226	.003017
	Total	9	1.85979	.492592	.164197
%Fibre	SAB	3	4.02153	.035302	.020382
	GAD	3	4.14090	.050145	.028951
	PEA	3	5.38860	.208391	.120315
	Total	9	4.51701	.664666	.221555
%CHO	SAB	3	36.65460	.467664	.270006
	GAD	3	35.54487	1.080947	.624085
	PEA	3	49.21517	1.391513	.803390
	Total	9	40.47154	6.638179	2.212726
β Carotene	SAB	3	90.2118	.54747	.31608
	GAD	3	142.2020	.57228	.33040
	PEA	3	134.2581	1.28227	.74032
	Total	9	122.2240	24.26598	8.08866

APPENDIX C

POST HOC TESTS OF THE CONSTITUENTS OF THE FORMULATIONS

Multiple Comparisons

Tukey HSD

Dependent Variable			(I) Sample		(J) Sample	Mean Difference (I-J)	Std. Error	Sig.
dimension1	%Moisture	dimension2	SAB	dimension3	GAD	.290567*	.079168	.024
					PEA	-.280767*	.079168	.028
			GAD	dimension3	SAB	-.290567*	.079168	.024
					PEA	-.571333*	.079168	.001
			PEA	dimension3	SAB	.280767*	.079168	.028
					GAD	.571333*	.079168	.001
	%Ash	dimension2	SAB	dimension3	GAD	-.067100	.110341	.821
					PEA	.036400	.110341	.942
			GAD	dimension3	SAB	.067100	.110341	.821
					PEA	.103500	.110341	.638
			PEA	dimension3	SAB	-.036400	.110341	.942
					GAD	-.103500	.110341	.638

%Protein	dimension2	SAB	dimension3	GAD	12.074200*	.455278	.000
				PEA	22.213167*	.455278	.000
		GAD	dimension3	SAB	-12.074200*	.455278	.000
				PEA	10.138967*	.455278	.000
		PEA	dimension3	SAB	-22.213167*	.455278	.000
				GAD	-10.138967*	.455278	.000
%Fat and Oil	dimension2	SAB	dimension3	GAD	.362967*	.053825	.001
				PEA	1.108167*	.053825	.000
		GAD	dimension3	SAB	-.362967*	.053825	.001
				PEA	.745200*	.053825	.000
		PEA	dimension3	SAB	-1.108167*	.053825	.000
				GAD	-.745200*	.053825	.000
%Fibre	dimension2	SAB	dimension3	GAD	-.119367	.102402	.513
				PEA	-1.367067*	.102402	.000
		GAD	dimension3	SAB	.119367	.102402	.513
				PEA	-1.247700*	.102402	.000

		PEA	dimension3	SAB	1.367067*	.102402	.000
				GAD	1.247700*	.102402	.000
%CHO	dimension2	SAB	dimension3	GAD	1.109733	.859388	.450
				PEA	-12.560567*	.859388	.000
		GAD	dimension3	SAB	-1.109733	.859388	.450
				PEA	-13.670300*	.859388	.000
		PEA	dimension3	SAB	12.560567*	.859388	.000
				GAD	13.670300*	.859388	.000

*. The mean difference is significant at the 0.05 level.

Multiple Comparisons
Tukey HSD

Dependent Variable		(I) Sample		(J) Sample		95% Confidence Interval	
						Lower Bound	Upper Bound
dimension1	%Moisture	dimension2	SAB	dimension3	GAD	.04766	.53347
					PEA	-.52367	-.03786
			GAD	dimension3	SAB	-.53347	-.04766
					PEA	-.81424	-.32843
			PEA	dimension3	SAB	.03786	.52367
					GAD	.32843	.81424

%Ash	dimension2	SAB	dimension3	GAD	-.40566	.27146
				PEA	-.30216	.37496
		GAD	dimension3	SAB	-.27146	.40566
				PEA	-.23506	.44206
		PEA	dimension3	SAB	-.37496	.30216
				GAD	-.44206	.23506
%Protein	dimension2	SAB	dimension3	GAD	10.67728	13.47112
				PEA	20.81625	23.61009
		GAD	dimension3	SAB	-13.47112	-10.67728
				PEA	8.74205	11.53589
		PEA	dimension3	SAB	-23.61009	-20.81625
				GAD	-11.53589	-8.74205
%Fat and Oil	dimension2	SAB	dimension3	GAD	.19782	.52812
				PEA	.94302	1.27332
		GAD	dimension3	SAB	-.52812	-.19782
				PEA	.58005	.91035
		PEA	dimension3	SAB	-1.27332	-.94302
				GAD	-.91035	-.58005
%Fibre	dimension2	SAB	dimension3	GAD	-.43356	.19483
				PEA	-1.68126	-1.05287
		GAD	dimension3	SAB	-.19483	.43356
				PEA	-1.56190	-.93350

		PEA	dimension3	SAB	1.05287	1.68126
				GAD	.93350	1.56190
%CHO	dimension2	SAB	dimension3	GAD	-1.52710	3.74657
				PEA	-15.19740	-9.92373
		GAD	dimension3	SAB	-3.74657	1.52710
				PEA	-16.30714	-11.03346
		PEA	dimension3	SAB	9.92373	15.19740
				GAD	11.03346	16.30714

Homogeneous Subsets

%Moisture

Tukey HSD[a]

Sample		N	Subset for alpha = 0.05		
			1	2	3
dimension1	GAD	3	12.32637		
	SAB	3		12.61693	
	PEA	3			12.89770
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

%Ash

Tukey HSD[a]

Sample		N	Subset for alpha = 0.05
			1
dimension1	PEA	3	5.58473
	SAB	3	5.62113
	GAD	3	5.68823
	Sig.		.638

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

%Protein

Tukey HSD[a]

Sample		N	Subset for alpha = 0.05		
			1	2	3
dimension1	PEA	3	21.83063		
	GAD	3		31.96960	
	SAB	3			44.04380
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

%Fat and Oil

Tukey HSD[a]

Sample		N	Subset for alpha = 0.05		
			1	2	3
dimension1	PEA	3	1.24200		
	GAD	3		1.98720	
	SAB	3			2.35017
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

%Fibre

Tukey HSD[a]

Sample		N	Subset for alpha = 0.05	
			1	2
dimension1	SAB	3	4.02153	
	GAD	3	4.14090	
	PEA	3		5.38860
	Sig.		.513	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

%CHO

Tukey HSD[a]

Sample		N	Subset for alpha = 0.05	
			1	2
dimension1	GAD	3	35.54487	
	SAB	3	36.65460	
	PEA	3		49.21517
	Sig.		.450	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

APPENDIX D
FUNCTIONAL PROPERTIES OF SWEET POTATO

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
B	3	.78	.005	.003	.77	.80
D	3	47.53	.306	.176	46.77	48.29
SP	3	4.21	.151	.087	3.84	4.58
%Solubility	3	30.82	.368	.212	29.90	31.73
WAC	3	195.36	.091	.052	195.13	195.58
Total	15	55.74	74.436	19.219	14.52	96.96

Descriptives

	Minimum	Maximum
B	1	1
D	47	48
SP	4	4
%Solubility	30	31
WAC	195	195
Total	1	195

ANOVA

Qty

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	77569.916	4	19392.479	373762.655	.000
Within Groups	.519	10	.052		
Total	77570.435	14			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

(I) functions	(J) functions	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
B	D	-46.750*	.186	.000	-47.36	-46.14
	SP	-3.427*	.186	.000	-4.04	-2.81
	%Solubility	-30.034*	.186	.000	-30.65	-29.42
	WAC	-194.573*	.186	.000	-195.18	-193.96
D	B	46.750*	.186	.000	46.14	47.36
	SP	43.323*	.186	.000	42.71	43.94
	%Solubility	16.715*	.186	.000	16.10	17.33
	WAC	-147.823*	.186	.000	-148.43	-147.21
SP	B	3.427*	.186	.000	2.81	4.04
	D	-43.323*	.186	.000	-43.94	-42.71
	%Solubility	-26.608*	.186	.000	-27.22	-26.00
	WAC	-191.146*	.186	.000	-191.76	-190.53
%Solubility	B	30.034*	.186	.000	29.42	30.65
	D	-16.715*	.186	.000	-17.33	-16.10
	SP	26.608*	.186	.000	26.00	27.22
	WAC	-164.538*	.186	.000	-165.15	-163.93
WAC	B	194.573*	.186	.000	193.96	195.18
	D	147.823*	.186	.000	147.21	148.43
	SP	191.146*	.186	.000	190.53	191.76
	%Solubility	164.538*	.186	.000	163.93	165.15

Multiple Comparisons

Tukey HSD

(I) functions	(J) functions	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
B	D	-46.750*	.186	.000	-47.36	-46.14
	SP	-3.427*	.186	.000	-4.04	-2.81
	%Solubility	-30.034*	.186	.000	-30.65	-29.42
	WAC	-194.573*	.186	.000	-195.18	-193.96
D	B	46.750*	.186	.000	46.14	47.36
	SP	43.323*	.186	.000	42.71	43.94
	%Solubility	16.715*	.186	.000	16.10	17.33
	WAC	-147.823*	.186	.000	-148.43	-147.21
SP	B	3.427*	.186	.000	2.81	4.04
	D	-43.323*	.186	.000	-43.94	-42.71
	%Solubility	-26.608*	.186	.000	-27.22	-26.00
	WAC	-191.146*	.186	.000	-191.76	-190.53
%Solubility	B	30.034*	.186	.000	29.42	30.65
	D	-16.715*	.186	.000	-17.33	-16.10
	SP	26.608*	.186	.000	26.00	27.22
	WAC	-164.538*	.186	.000	-165.15	-163.93
WAC	B	194.573*	.186	.000	193.96	195.18
	D	147.823*	.186	.000	147.21	148.43
	SP	191.146*	.186	.000	190.53	191.76
	%Solubility	164.538*	.186	.000	163.93	165.15

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

Tukey HSD[a]

Functions	N	Subset for alpha = 0.05				
		1	2	3	4	5
B	3	.78				
SP	3		4.21			
%Solubility	3			30.82		
D	3				47.53	
WAC	3					195.36
Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

APPENDIX E
ACCEPTABILITY OF FOOD SAMPLES

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Appearance	Between Groups	41.156	3	13.719	11.495	.000
	Within Groups	262.554	220	1.193		
	Total	303.710	223			
Taste	Between Groups	4.121	3	1.374	.654	.581
	Within Groups	462.125	220	2.101		
	Total	466.246	223			
Texture	Between Groups	6.625	3	2.208	.422	.738
	Within Groups	1152.214	220	5.237		
	Total	1158.839	223			
Aroma	Between Groups	1.835	3	.612	.444	.722
	Within Groups	302.875	220	1.377		
	Total	304.710	223			
Overall Acceptability	Between Groups	7.161	3	2.387	1.708	.166
	Within Groups	307.393	220	1.397		
	Total	314.554	223			

Post Hoc Tests

Overall Acceptability
Tukey HSD[a]

Formulations		N	Subset for alpha = 0.05
			1
dimension1	SAB	56	3.52
	PEA	56	3.64
	GAD	56	3.66
	KAN	56	4.00
	Sig.		.138

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 56.000.

APPENDIX F
INTRODUCTORY LETTER

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF VOCATIONAL AND TECHNICAL EDUCATION

Direct 03320-91097 :
Telegrams & Cables: University, Cape Coast

University Post Office
Cape Coast, Ghana

Our Ref: VTE/I.7/Vol.1/434

18th November, 2016

The Chairman
Institutional Review Board
U. C. C.

Dear Sir,

INTRODUCTORY LETTER

We have the pleasure of introducing to you Esther Kumea Ashun who is an M. Phil student at the Department.

We would be very grateful if you could grant her ethical clearance to enable her obtains data for her thesis on the topic **"Orange Fleshed Sweet Potato: its use in Complementary Infant Formular".**

We are counting on your usual cooperation.

Thank you.

Yours faithfully,

Dr. (Mrs.) Christina Boateng
HEAD OF DEPARTMENT

APPENDIX G

ETHICAL CLERANCE TO COLLECT DATA

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 03321-33172/3 / 0207355653/ 0244207814
E-MAIL: irb@ucc.edu.gh
C/O Directorate of Research, Innovation and Consultancy

OUR REF: UCC/IRB/A/2016/56
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

31ST JANUARY, 2017

Ms. Esther Kumea Ashun
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms Ashun,

ETHICAL CLEARANCE –ID :(UCCIRB/CES/2016/16)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research protocol titled **'Orange fleshed sweet potato: Its use in Complementary infant formula.**

This approval requires that you submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

Please note that any modification of the project must be submitted to the UCCIRB for review and approval before its implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST

Samuel Asiedu Owusu Date: ....
Administrator

APPENDIX H
PERMISSION TO CONDUCT SENSORY EVALUATION ON UCC HOSPITAL PREMISES

Department of Vocational and Technical Education.
University of Cape Coast,
18th April, 2017.

The Director,
University of Cape Coast Health Services,
Cape Coast.

UNIVERSITY HOSPITAL
RECEIVED
1 0 APR 2017
UNIVERSITY OF CAPE COAST

Dear Sir,

PERMISSION TO CONDUCT SENSORY EVALUATION TEST ON YOUR PREMISES

I am Esther Kumea Ashun, an Mphil. Student conducting a research on the topic: Orange fleshed sweet potato: Its use in complementary infant formula. As part of my work I have developed a food for babies and will like to find the acceptability level from the babies with the help of their mothers (6 – 24months) who visit your health centre. My selection will be solely based on the parents' willingness to participate in the study.

com

I humbly seek for your permission to conduct my sensory evaluation test on your premises. Attached is an ethical clearance letter from the University of Cape Coast Institution Review Board.

Counting on your usual co-operation.

Thank you.

Yours faithfully,

Esther Kumea Ashun
0244974273

APPENDIX I
ENGLISH VERSION

Consent forms for participating in sensory evaluation of orange fleshed sweet potato complementary food.

I am investigating the sensory qualities of complementary foods made from orange fleshed sweet potatoes, anchovies, onion and tomatoes. These complementary foods are to help reduce vitamin A deficiency among Ghanaian weaning babies. Responding to this questionnaire will take about 15 minutes of your time. The following is a list of ingredients in the complementary foods: orange fleshed sweet potatoes, anchovies, onion, and tomatoes

Should you be allergic to any of the above ingredients; please do not volunteer for thisstudy.

If you agree to participate in this study please sign the consent form provided. Confidentiality and anonymity is assured. Your participation in this study is voluntary and do not hesitate to withdraw anytime you decide to. If you have any questions regarding this study, please contact:

Esther Kumea Ashun 0244 974 273

I have read the information presented above and voluntarily agree to participate in thisstudy

__________________________ _____________________

Participant’s signature Date

APPENDIX J:

TRANSLATED VERSION OF CONSENT FORM

Krataa a Ɔkyerɛ dɛ agye atomu.

Krataaaa Ɔkyerɛ dɛ agye atomu dɛ ɛbosƆ mbofra edziban a wƆdze santom a noho Ɔrengye ayɛ ahwɛ.

Yɛreyɛ nhwehwemu afa mbrɛ mbofra edziban a wƆdze santom a noho Ɔrengye, nam nketsenketse (amoni), anwew na tomantese ayɛ ho. Yɛdze ndzɛmba a yedua no fie no yɛɛ edziban no dɛ ƆbƆboa ma y'abrɛ yarba a Ghana mbofra a wonnyi Vitamin A no nya no ase. Yɛpɛ dɛ ɛma wƆho sima du-enum, edze ka edziban no mo kor biara hwɛ na ekyerɛ w'adwen fa ho.

Nndzɛmba a wƆ dze yɛ edziban no na odzidzi do no santom orange, amoni, anwewna tomantese

Sɛ ikyir ndzɛmba a wƆ dze yɛɛ dɛm edziban yi mu bia mɛsrɛ mma nnfa woho nhyɛ dwumdzi yi mu.

Mbueye a edze bɛma nsɛmbisa no rennkyerɛ obiara ne dzin. .

Dwuma a rebedzi wƆ nhwehwɛmu yi mu no yɛ etuhoakyɛ. Sɛ ɛmmpɛ dɛ ɛyɛ anaa esƆw do a, yɛbɛ gye atomu ntsɛmara wƆ akoma pa mu. Sɛ ɛwƆ nsɛmbisa a Ɔfa nhwehwɛmu yi ho a, ibotum afrɛ

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Maakankan asɛm a ƆwƆ sor no na megyetum dɛ medze moho bɛhyɛ dwumadzi yi mu.

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NyeaƆkaho ne dapaa Da