UNIVERSITY OF CAPE COAST

USE OF PEARL MILLET IN COMPLEMENTARY INFANT FORMULA

MARTINA BATIDOW APOLALA

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University of Cape Coast

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BY

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DECLARATION

Candidate's Declaration

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

Candidate's Signature.......................................Date..

Name: Martina Batidow Apolala

Supervisor's Declaration

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

Principal Supervisors Signature................................ Date. ....

Name: Prof. Mrs. Sarah Darkwa

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ABSTRACT

A complementary food was developed from pearl millet, dawadawa, herring, tomatoes and onion to help reduce the menace of malnutrition and anemia deficiencies among infants. Experimental research design was used for the study. Fifty-five infants of ages 6- 24 months were purposively sampled, together with their mothers, to evaluate 3 complementary food samples code named Apolala Diet Blend, Pearl Apolala Diet Blend and Apolala Pearl Diet Blend and a control Control. A questionnaire was used to collect data. The samples were formulated from Pearl millet, dawadawa, herring, tomatoes and onion. The nutrients and functional properties determined. The results showed that the 3 complementary foods were nutrient dense with high protein content highest in Apolala Pearl Diet Blend and the least in Pearl Apolala Diet Blend. Although Pearl Apolala Diet Blend had the least in protein content, it turned out to have the highest ash content. Apolala Diet Blend, Pearl Apolala Diet Blend and Apolala Pearl Diet Blend were all high in carbohydrates and fibre but lower in moisture and fats, Apolala Diet Blend had the highest B-carotene content. Pearl Apolala Diet Blend had the highest bulk density and least B- carotene. The water absorption capacity was higher in Apolala Pearl Diet Blend, giving it a high Swelling Power whiles Apolala Diet Blend had the least water absorption capacity. Apolala Diet Blend recorded the highest Solubility index Pearl Apolala Diet Blend on the other hand had low Swelling Power. Control was the most accepted, followed by PADB, APDB and ADB although it was not significantly different from these 3. Comments received from the evaluation by panellists showed that probably making the texture smooth and improving the colour would make all the 3 products liked as the ontrol.
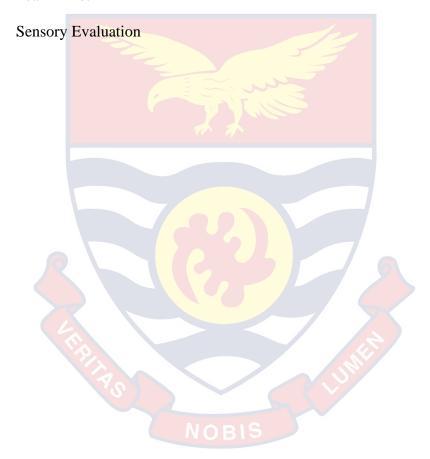
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KEY WORDS

Anemia

B-carotene

Complementary food

Infants

Malnutrition

Pearl millet

Sensory Evaluation

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DEDICATION

To my parents, family, and. friends

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LIST OF ACRONYMS

AOAC   Association of Official Analytical Chemists

FAO   Food and Agriculture Organization

FAOSTAT   Food and Agriculture Organization Statistic

G   Gram

Mg   Milligram

ml   Millilitre

PMF   Pearl Millet Flour

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

WHO   World Health Organization

ADB   Apolala Diet Blend

APDB   Apolala Pearl Diet Blend

PADB   Pearl Apolala Diet Blend

CBA   Cost Benefits Analysis

WTP   Will to Pay

WTA   Will to accept

NPV   Net Present Value

PV   Present value

CHAPTER ONE

INTRODUCTION

Background to the Study

Malnutrition is a health disorder which occurs when an individual has either too much or too little food energy or nutrients, thus it covers over nutrition and under-nutrition. There are several factors that contribute to malnutrition. The main contributing factors for under five stunting are sex and age of a child, diarrhea episode, deprivation of colostrum at birth, duration of breastfeeding, pre-lacteal feeds, type of food, age of introduction of complementary feeding and method of feeding (Logan, 2019). Infant and young child feeding (IYCF,) recommend exclusive breastfeeding up to six months from which there should be timely initiation of feeding of semi-solid to solid foods. In addition, Alina (2008) endorse feeding small amounts at the introduction stage of the complementary food and gradually increasing the amount of foods and frequency of feeding as the child gets older, while maintaining breast feeding as demanded by the child.

The essence of the recommendation of six months exclusive breastfeeding before the introduction of semisolid to solid foods, is to help prevent certain diseases which can result in infant morbidity and mortality. There is a strong evidence that human milk feeding decreases the incidence and or severity of a wide range of infectious diseases including bacterial meningitis bacteraemia, diarrhoea, respiratory tract infections, necrotizing enterocolitis, otitis media, urinary tract infection and late-onset sepsis in preterm infants (Alina, 2008; Cochi, Fleming & Hightower, 2003; Kramer, Guo & Platt, 2003; Marild, Hansson, Jodal, Oden, & Svedberg, 2004; Eisenberg, Neumark-Sztainer

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& Story, 2003). It has been found that, post-neonatal infant mortality rates in the United States reduced by 21.00% in breastfed infants (Mathews, MacDorman, & Thoma, 2015). It is no doubt that the World Health Organization (WHO) and The American Academy of Pediatrics recommend that an infant be breast-fed without supplemental foods or liquids for the first six months of age (also known as exclusive breast feeding). These recommendations for exclusive breastfeeding for the first six months are based on scientific evidence of the benefits for infant survival, growth, and development (WHO/NUT/98.1.). The breast milk is noted as the ideal first meal for the newborn infant and providing an adequate supply of human breast milk is known to satisfy virtually all the nutritional requirements such as vitamins A, B6, iron and calcium of an infant for the first six months of life and beyond. This shows that any other food (complementary) given after the first six months should be able to provide needed nutritional requirements that the breast milk could provide.

Complementary feeding (CF) is another very important component of infant feeding. After 6 months, mother's milk alone is not enough for the growing child and complementary feeding should be started, timely and in adequate amounts with good quality. Frequency, quality and amount of top feeds given during the weaning period to children are important factors in the pathogenesis of malnutrition. Inappropriate feeding practice during this period is found to be the major cause of malnutrition (WHO/NUT/98.1.) Adequate nutrition is essential for normal child's growth and development. Globally, under nutrition affects more than 50% of the children especially those under 5

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years of age and remains one of the most common causes of morbidity and mortality (Lodha & Bharti, 2013; Sethi, Kashyap & Seth, 2003; WHO, 2002).

Malnutrition in children under 5 years may not simply be a result of food insecurity. Many children in food secure environments and from fair socio-economic backgrounds are malnourished probably as a result of inadequate knowledge of breast feeding and complementary foods, poor feeding practices and food restrictions due to cultural belief (Cordula, 2003). These factors are often greater determinants of malnutrition than even the availability of food itself. The mother is the main caregiver and the key person in the prevention of malnutrition since the children completely depend on their mothers for their nourishment (Abubakar, Holding, Mwangome, & Maitland, 2011; Sethi, Kashyap, & Seth, 2003). A mother's chance of preventing under nutrition is likely to be increased if she has the right knowledge or information on how to feed her children as well as on the nutritional element to be present in the complementary food.

According to WHO (2002), adequacy of complementary foods depends on the availability of food as well as the caregiver feeding practices. Studies shows that exclusive breastfeeding in the first 6 months and the introduction of complementary feeds at 6 months with continued breastfeeding for at least 2 years can decrease infant mortality by 19 per cent. Complementary feeding makes up for insufficient breast milk to the baby infant after 6 months. However, inappropriate quality, quantity, frequency and consistency of complementary foods can make the child more susceptible to infection, slower in recovery after illness and higher mortality (GHS, 2016).

A survey conducted in 2017 by the World Vision Ghana (WVG) to see how breastfeeding mothers were doing in four Area Development Programme (ADPS), namely Eekyere East, West Gonja, Asante Akim and Savalugu in Ghana, noted that West Gonja had 81 percent when it came to exclusive breastfeeding until six months of age which was even above the national percentage of 52 per cent. It was further observed that the children that were exclusively breastfed in that area were not stunted but had the right age for height. However, a follow up survey conducted revealed that after the exclusive breastfeeding there was the prevalence of stunting among children less than five years. This could be attributed to lack of sufficient nutrients in the complementary food introduced after exclusive breastfeeding. On the average, stunting and wasting stood at 31 percent and 11 percent respectively in the four ADPs. Stunting was considerably higher compared to the global rate of 23 percent (Global Nutrition Report, 2016). West Gonja recorded stunting 28 percent and wasting 19 percent which was above the national percentage of 19 percent and 5 percent respectively and the global percentage of 23 percent and 8 percent respectively. Factors such as large family size, unavailability of food, poverty and poor feeding practices were noted to have contributed to the high malnutrition among children in the district.

The UNICEF (2014) reported a map indication of the malnutrition level in the country Ghana. From the map, Northern Region had the highest percentage of 37.4% as compared to the other regions. Below is the map that indicates malnutrition in the country MICS (2014) report.

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WHY NUTRITION
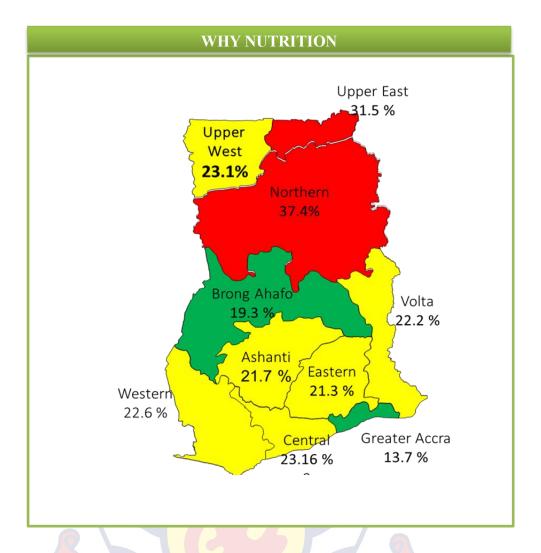
Figure 1: Malnutrition level in Ghana.

Source: MICS, 2014

The three Annual Trends in Routine Growth Monitoring and Promotion for the sub-district and district of West Gonja from 2016, 2017 and 2018 on attendance, underweight and normal. The percentage of the underweight in the sub- district and district made the nutritional unit put the following measures in place;

The nutrition unit was placed under the District Health Directory (DHD) is to coordinate all nationally directed nutrition programmes and activities. This unit was to also collaborate with agencies and other stakeholders with concern in nutrition to equip the populace in West Gonja District with the requisite

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capacity to tackle malnutrition with the view of reducing the nutrition indicators to the barest minimum using the multi-sector approaches. Work for the empowerment and capacity development of families and communities as Primary Child Caregivers (PCC) through nutritional therapy, Education and Advocacy to meet specific objectives of the district, region as well as national nutrition policy framework. The following is the table representation and graph presentation of the three Annual Trends on Routine Growth Monitoring and Promotion.

Millet (pearl variety) for example, is grown and promoted in Ghana especially in the three Northern Regions of Ghana by the Ministry of Food and Agriculture and can easily be obtained. The dawadawa is also a common tree found in the Northern Region, which can also be easily accessed. The dawadawa for instance is high in protein, vitamins, carbohydrates and minerals. Increasing the use of pearl millet, dawadawa and herrings in the diet of children may be an excellent way to reduce stunting and wasting in Ghana.

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Table 1: Annual trend on routine growth monitoring Promotion

SUB-DIST.	2016			2017			2018		
	Att.	(%) Under weight	Normal	Att.	(%) Under weight	Normal	Att.	(%) Under weight	Normal
Busunu	6968	262 (3.8%)	6706 (96.2%)	3927	110 (3%)	3298	10976	154 (1.4%)	10827
Canteen	4137	795 (19.2%)	3342 (80.8%)	2856	104(4%)	2562	6131	223 (3.6%)	5873
Damongo	5138	113 (2.2%)	5025 (97.8%)	2045	66(3%)	1387	5405	40(0.7%)	4498
Larabanga	8156	209 (2.6%)	7947(97.4%)	3894	148(4%)	3783	8557	82(1.0%)	8436
DASS	1610	86(5.3%)	1524 (94.7%)	2755	69(3%)	2751	6254	168 (2.7%)	6086
District	26009	1465 (5.6%)	24544 (94.4%)	15477	497(4%)	14980	37323	667 (1.8%)	35720

Source: MICS (2014)
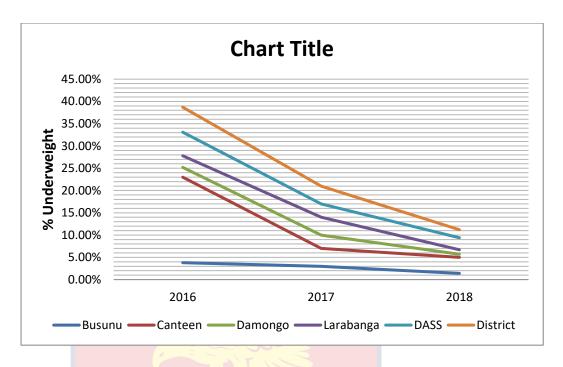
Figure 2: Chart on underweight

Source: MICS, 2014

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 cereal only or blended with legumes. Most mothers who cannot afford the commercially produced complementary food may decide to prepare some by themselves for their babies. Mothers may lack the knowledge on how to combine certain food items that could provide the needed nutrients required for their babies. A baby that consumes complementary foods that lack nutrients such as, protein, vitamins, minerals and carbohydrate is likely to be stunted. However, there are some food items that are not costly but reasonable and when combined in the complementary foods could provide the needed nutritional requirements for a baby. Such food items include pearl millet, finger millet, groundnut, dawadawa and onion.

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As indicated by UNICEF Ghana (2011) there is an estimated prevalence rate of 23 per cent of stunted children and 57 per cent of anaemic children in Ghana, although levels of malnutrition have dropped. Nutrition is found to be particularly poor in Northern Ghana, where almost two in every five children are stunted and more than 80% of children suffer from anaemia (UNICEF Ghana, 2011).

It has been observed that mothers in the northern part of Ghana usually prepare complementary foods from either only milled pearl millet flour for preparing porridge, the combination of roasted maize, groundnut and beans milled also into flour for preparing porridge or introducing the slimy soup with Tou Zaafi. With these foods available stunting persists among children from these areas. This could be attributed to lack of adequate nutrients in these foods, poor feeding practies and also not having access to other nutritious foods because they cannot afford. It in view of this, the researcher developed complementary food from pearl millet, dawadawa and herrings that are less expensive, more affordable, nutritious and can help reduce malnutrition especially among infants in West Gonja District and its environs.

From the outcome of the 2017 survey there was every indication that there was still a gap between the exclusive breastfeeding and the introduction of complementary food in West Gonja. This may be due to the lack of adequate nutrients and the cost of some existing complementary foods used by mothers in the area. It is in this view that the researcher used some local food items to formulate an infant formula that was more reasonable and less expensive, nutritious and cost effect. These local food items include pearl millet, dawadawa, herring, tomatoes and onion.

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Objectives of the Study

The main purpose of the study was to formulate complementary foods from some local food items namely pearl millet, dawadawa, herrings, onion and tomatoes.

Specifically, the study sought to:

1. develop a complementary food from pearl millet, herring, dawadawa, tomatoes and onion

2. examine the chemical constituents of the developed complementary food

3. determine the functional properties of the complementary food being formulated.

4. sensorily evaluate the acceptability of the complementary food in terms of: appearance, taste, texture, aroma and overall acceptability.

5. compare the cost of the same amount of the control to the developed complementary infant food.

Hypotheses

Ho1: There is no statistically difference between the sensory properties of the developed complementary food ADB (APOLALA Diet Blend) and commercially manufactured (cerelac millet).

Ho2: There is no statistically difference between the sensory properties of the developed complementary food PADB (Pearl Apolala Diet Blend) and the commercially manufactured (cerelac millet).

Ho3: There is no statistically difference between the sensory properties of the develop Complementary food APDB (Apolala pearl Diet Blend) and commercially manufactured (cerelac millet).

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Ho4:   There will be no statistically difference among the three products developed in terms of their nutritional content and that of cerelac millet.

Significance of the Study

It is hope that these new products will go a long way to help reduce the persistent stunting and anaemia problem among infants in the Northern region of Ghana. The ingredients used in producing the complementary baby food are underutilized and if accepted could help promote these locally grown food items at reasonable cost could help mothers obtain these foods and feed to their babies for good growth and development. Producing more of these food items could help increase the earnings of the families engaged in the production of these items. These millet products could add varieties to the already known complementary foods. The study will help industry player to use it as a prototype to produce in large quantity when the shelf life of the product has been study. This study will also help policy makers to achieve the sustainable goal two which aims to end all forms of hunger and malnutrition by 2030, the study will as well help policymakers to help solve the statement of USAID accelerating progress in nutrition in January, 2018 which state that the consequences of malnutrition should be of significant concern for policymakers in Ghana due to the prevalence of undernutrition, overnutrition and micronutrient deficiencies and also Ghana's commitment to improving nutrition, which is aligned with the government's vision 2020.

The method employed in this study can be adopted by NGOs, household, companies and community levels to produce nutrient dense complementary foods to help reduce the menace of malnutrition and anaemia deficiencies

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among infants in Ghana and especially Northern region where malnutrition and anaemia is high.

Delimitation

Even though there are other formulated complementary foods, the study focused on the formulation of complementary food from pearl millet, dawadawa, tomatoes, onion and herrings. The study was a hospital-based study conducted among infants aged 6 - 24 months who attend child welfare clinic. Lodha, & Bharti, 2013

Limitations

Due to 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 talk, so the responses obtained using facial expressions may not fully be representative of what they may be trying to communicate.

Presentation of work

This report is organized to five chapters. Chapter one covers the background of the study, problem statement, objectives and scope of the study. Chapter two looks at the review of related relevant literature on the pearl millet, dawadawa, Herring, onion and tomatoes. Chapter three gives a description of the methods, materials, tools, procedures used in gathering information and analyzing the data. Chapter four focused on presentation of results in the form of tables, charts and the discussion of results/findings. Chapter five focused on conclusions and recommendations of the study.

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CHAPTER TWO

LITERATURE REVIEW

This chapter presents relevant related literature to the study. It begins with a review of the origin and distribution of pearl millet, agronomic characteristics and cultivation of pearl millet, post-harvest storage of pearl millet. Economic importance, utilization of pearl millet, nutritional value, health benefit of pearl millet and proximate composition of pearl millet.

It also reviews the origin and distribution of tomatoes, nutritional and health benefits of dawadawa, origin and distribution of herring, nutritional and health benefits, origin and distribution of onion, nutritional and health benefits of onion, effect of dehydration, functional characteristics of pearl millet flour, and complementary food from pearl millet and sensory evaluation of food product.

Nutritional Benefits of Millet

Millet is unique among the cereals because of their richness in calcium, dietary fibre, polyphenols and protein (Devi *et al., 2011*). According to (Obilana & Manyasa, 2002), millet generally contain significant amounts of amino acids particularly the Sulphur containing amino acids i.e. methionine and cysteine. Millet as an alternative to the more common grains is rich in phytochemicals, including phytic acid. Which is believed to lower cholesterol, and phytate, which is associated with reduced cancer risk (Coulibaly, Kouakou, & Chen, 2011). Millet contains appreciable levels of the B-vitamins, thus vitamin B1, B2 and B5 and vitamin A and C (Nambiar, Dhaduk, Sareen, & Desai, 2011). It has also been reported to contain some appreciable levels of folic acid. According to Veenu and Patel (2012), millet contains a good source of minerals namely;

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magnesium, manganese and phosphorus. Research has linked magnesium to a reduced risk for heart attack and phosphorus is important for the development of body tissue and energy metabolism.

Health benefits of Nutrient of Millet

The nutrient in millet has much health benefit for the humans. The following are some of the health benefits of millet.

1. Millet helps in weight loss

2. Millet is a rich source of magnesium, a mineral which is extremely important for starch digestion.

3. Magnesium makes many carbohydrate-digesting enzymes, even the ones which manage insulin's action. Researches find that magnesium-rich whole grain consumption can help lower the risk of type-2 diabetes.

4. Millet contains phytonutrients and the one which is present in high quantity millet is lignans. Lignans are known to be prebiotic fiber, which is fermented in our gut by bacteria, as per the studies, upon fermentation, they yield enterolactone, a product which is known to protect against heart disease and some form of breast cancers.

5. Millet contains insoluble fibre so consuming foods high in insoluble fibre could prevent the occurrence of gallstones.

6. Combination of whole grains like millets and fish help reduce the incidence of wheezing in children. For the purpose of this study the researcher limited it to the pearl millet.

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About Pearl Millet

According to Kulthe et al. (2016) pearl millet (*Pennisetum glaucum* L) is recognized as being the most widely grown of all the millet types. It is the basic staple food in the poorest countries and used by the poorest people. For human consumption it can be used in a variety of ways including both leavened and unleavened breads, in porridges, and can also be boiled or steamed. It is also used as an ingredient in the production of alcoholic beverages. Apart from its grains, its stems are used as building materials and as a fuel. It is also widely used in poultry farming and egg production. More recently it has found its way into the pet market, and the most profitable current market where it is used as an ingredient in bird seed mixes.

Nutritionally pearl millet is comparable and even superior to major cereals with respect of energy value, proteins, fat and minerals. It makes an important contribution to human diet due to high levels of calcium, iron, zinc, lipids and high-quality proteins. Besides, it is also a rich source of dietary fibre and micro-nutrients (Malik et al., 2002; Sehgah & Kawatra, 2006). Since prehistoric times, pearl millet has been grown prominently in Africa and Indian Subcontinent. It is believed that pearl millet originated in Africa and was later introduced to India. The earliest archaeological evidences show that millet was cultivated in India around 2000 BC; hence, domestication in Africa must have taken place before that (Malik *et al.,* 2002; Sehgah & Kawatra, 2006).

The most widely grown millet, the pearl millet, is known for its culinary uses as well as health benefits. It is cultivated in countries of Africa and the Indian subcontinent since prehistoric times. Pearl millets, earlier known as 'bird food', come in several delicious flavours. What is unique about this cereal is

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that it may be as creamy as mashed potatoes or as fluffy as rice. In India, pearl millets are regarded as one of the major sources of dietary energy and nutritional security for poor farmers and consumers. Apart from offering excellent taste, these millets contain essential mineral and nutrients, which provide the body with a variety of advantages.

Health Benefits of Pearl Millet

Millets are a great source of starch, making it a high-energy food and It is also an excellent source of protein and fibre. the amino acids in the pearl millet are reported to be easily digestible than the ones found in wheat. Pearl millet is packed with essential nutrients such as methionine (an amino acid), B complex vitamins (niacin, thiamin, and riboflavin), folic acid, lecithin, potassium, magnesium, manganese and zinc, millets are very effective in several roles and it has high levels of niacin which reduces cholesterol while magnesium is essential for maintaining good heart health, as it lowers blood pressure and reduces the risk of heart attacks.

Pearl millet is a rich source of phosphorus, which is an important part of the structure of body cells. Phosphorus, found in pearl millets, is a significant component of several necessary compounds including adenosine triphosphate (ATP). This element is also a crucial component of nucleic acids, which are the building blocks of the genetic code. Phosphorus is a constituent of lipid-containing structures such as cell membranes and nervous system structures.

Recent studies have proven that regular consumption of pearl millets help in preventing gallstones in women and they contain insoluble fibres which speed up intestinal transit time but also reduces the secretion of bile acids. Pearl millets are known to increase insulin sensitivity and lower the level of

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triglycerides. Regular intake of millets provides protection against breast cancer in pre-menopausal women. Apart from that, it has also shown a considerable reduction in the occurrence of wheezing and asthma in children.

Millets contain an essential phytonutrient, lignin, which is very beneficial for the human body. With the help of natural flora, lignans get converted to mammalian lignans and they fight against hormone dependent cancers and reduce the risk of cardiac arrests. Consumption of pearl millets helps in minimizing the risk of type 2 diabetes. Being a good source of magnesium, millets act as a cofactor in several enzymatic reactions.

Challenges Associated with Millet Production

According to SRID (2011), Pearl millet is grown mainly in the three Administrative regions of Northern, Upper East and Upper West (covering 29% total land area) of Ghana. According to Policy Planning Monitoring and Evaluation Division of the Ministry of Food and Agriculture (PPMED, 1991), in 1990 an estimated 244,000 hectares of land put to millet production yielded 80,000 tonnes of grain. In 2010 (20 years later), the actual cropped area declines to 177,000 hectares but grain yields increased to 219,000 tonnes (SRID, 2011). This increase in yield could be attributed to the prudent and efficient management practices adopted by farmers and not as a result of farmers using improved seeds (SRID, 2011).

Despite these increments, millet seems to have limited uses; with very common uses fura/fula, tuozaafi, gruels, "kapouno", "kapuka" (type of meal by the people of Upper East using pearl millet), and beverage. According to (Obilana, 2003). The steam cooked Couscous, as well as bouilles, is commonly consumed in the Francophone countries including Senegal, Mail, Guinea,

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Burkina Faso, Niger and Chad. In Nigeria and Niger, the thin porridge Fourra is very popular while Soungouf; Sankhal and Araw are very popular in Senegal. Fermented thick porridges are popular in Niger, Sudan and Southern Africa, while fermented thin porridges are commonly consumed in West Africa especially Nigeria and Ghana (ogi, koko, akamu, kunu) and East Africa mostly in Kenya and Uganda (uji) where souring with lemon is used instead of fermentation.

Nevertheless, the utilization of millets is limited due to the presence of various anti-nutrients. Pearl millet is often rich in fibre-associated anti-nutrients namely phytate, oxalate and tannins which have a negative influence on the bioavailability of minerals, also causing poor digestibility of proteins and carbohydrates (Taylor, 2004). Due to the presence of the fibrous seed coat, the flour of pearl millet is coarse and has a grey to yellow colour which impacts a bitter taste and the products prepared from the whole flour have low consumer appeal (Kulthe, Thorat, & Khapre, 2018). This may be a reason for its poor acceptability by rice/wheat consumers.

According to Saleh, Zhang and Chen (2013), the utilization of millet grains as food is still limited to populations in the rural areas at the household level. Moreover, it is generally still being regarded as the poor man's food and does not find place in the food purchase list of "elites". According to Saleh *et al*. (2013), the onset of problems such as climate change, water scarcity, increasing world population, rising food prices and other socioeconomic impacts in this 21st century, are expected to generate a great threat to agriculture and food security worldwide, most especially for the poorest people who live in dry and sub-dry regions. Given its limited use but great nutritional potential,

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employing it in a complementary food may help widen the utilization of millet. This will also help make available the various nutrients such as the protein, carbohydrate, minerals, B-vitamins, vitamin C, A and folic acid for infant nutrition.

Proximate Composition of Pearl Millet

Kulthe et al. (2016) carried out a research to characterize three pearl millet cultivars for proximate composition. The samples were evaluated for moisture, crude fat, crude protein, crude fibre, ash content and carbohydrate using standards (Kassegn, 2018). The proximate composition plays an important role for deciding nutritional and functional qualities of flour. The following amounts of nutrients were recorded in the different cultivars of pearl millet. The moisture, ash, fat, protein, crude fibre and carbohydrate content ranged from 11.21-12.43%, 2.05-2.72%, 5.14-5.96%, 10.97-11.65%, 2.07-2.63%, and 66.49-68.85%, respectively. Proximate composition of pearl millet was found to be varied from 88-91% dry matter, 1.6-2.4% ash 2.6-4.0% crude fibres, 2.7-7.1% fat, and 8.5-15.1% proteins (Kulthe, Ihorat & Lande, 2016; Ojokoh, Fayemi, Ocloo & Nwokolo, 2015). Also, an observation was done on raw pearl millet flour and the nutrients were 14.0% protein, 5.7% fat, 21% ash, 2.0% crude fibre and 76.3% carbohydrates (Fasasi, 2009). Florence et al. (2014) recorded that semi-refined flour of two pearl millet varieties contained 10.8 % and 9.5% moisture, 8.5 and 10.1 % proteins, 4.4 % and 5.0 % fat, 1.3 % and 1.3% ash and 75.0 % and 75.0% carbohydrate respectively. The values obtained for proximate composition of pearl millet were within the range reported in literature (Kulthe, Ihorat, & Lande, 2016; Ojokoh, Fayemi, Ocloo & Nwokolo, 2015).

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About Dawadawa

Dawadawa is obtained from a fermented seed of a tropical tree plant; *Parkia biglobosa* commonly called African locust bean. It is commonly used in some Ghanaian homes as a condiment in varieties of meals. Fermented seeds of the African locust bean are used mostly in all parts of Northern Ghana and the West Coast of Africa for seasoning traditional soups. The Hausa people call it Dawadawa, Kassem people call it Choo, the Frafra call it Kulgo, in Ghana and the Yoruba call it Iru or Iyere and the Igbo people call it Ogiri in Nigeria. Dawadawa is a black strong-smelling tasty seasoning, rich in lipid 29%, protein 35% and carbohydrate 16%. It is thus a good source of protein, fat and calcium especially for rural the dwellers.

Dawadawa is popularly used in seasoning traditional soups, such as dried powdered okro soup, Alefu soup, bitter-leaf soup (Onugbu in Igbo) palm nut soup has shown great promise in boosting cellular immunity in immune-compromised persons, as well as, in the management of diarrhea, diabetes, and heart attack. It could also serve as an antidote to snake bites (Akubire Mbena Sampson, 2018). Traditionally, dawadawa is also used extensively in the treatment of hypertension and some infectious diseases or illnesses (Kisseih, Kretchy, Sarkodie, Okraku, Sasu, Adjei, & Twumasi, 2017).

An aqueous extract from dawadawa has been reported to have inhibiting effect on the platelet secretion and aggregation (Teye, Taame, Bonsu, & Teye, 2013). Dawadawa is a condiment. These are dried seeds, fruits, root, back, leaves or vegetative substances used in small quantities as food additives for the purpose of enhancing flavour, colour, or as a preservative (Thomas, 2007). FAO (2010) reported that spices and condiments in food minimizes the rate of

rancidity, improve colour and flavour intensity of food and food products. However, there are some indigenous spices and condiments used in Ghanaian homes for enhancing the flavour of traditional dishes. Dawadawa is one of such ingredients.

Dawadawa is used mainly as a flavouring agent but also improves the nutritional composition of poor-protein diets (Dike & Odunfa,2003; Ikenebomeh *et al.,* 1986). According to Shao (2002), dawadawa is currently used in local homes as an additive that adds protein to most stews and soups. Its crude protein content is reported to range from between 23.5% to 33.4%, depending on the duration of fermentation of the seeds (Dike & Odunfa, 2003). Dawadawa is also an important source of Vitamin B (Shao, 2002). Vitamin B in the form of riboflavin is generally deficient in most African diets, but a substantial amount of this is available in Dawadawa (Shao, 2002). They sometimes come with offensive odour but are used to make delicious meals.

Nutritional Value

Dawadawa is rich in the following nutrients, Phosphorus, Calcium, Potassium, Ascorbic acid, Tannin, Oxalate, Protein, Carbohydrate, Sucrose, Polyphenol, Lipid and Carotenoids

Health Benefits of Dawadawa

Consumption of dawadawa help in getting rid of toxins from the body since it has great antioxidant properties. It is used in the preparation of meals especially as a condiment that adds flavour to food. It is well known for treating high blood pressure. Constant consumption of dawadawa improves eyesight and often corrects most eyes defect.

Dawadawa when consumed is known to be used for treating hypertension and stroke. The pulped bark of the African Locust Bean is used along with lemon for treating wound and ulcers. The bark of *Parkia biglobosa* is used as a bath for fever treatment, as a hot mouthwash to steam and relieve toothache. Fermented dawadawa seeds can be for controlling diabetes and lower cholesterol

Origin and Distribution of Tomato

Tomatoes *Solanum lycopericum* 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 around the globe (Srinivasm, 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, sauces and in drinks.

Nutritional and Health Benefits of Tomatoes

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, potassium and folate. It contains high levels of antioxidants. β-carotene and lycopene. One medium sized tomato has 552 meg of β-carotene and 3,165 meg of lycopene which can help boost the immune system by fighting the damaging effects of substances called free radicals (Mann, 2010). According to Sun, Simon, and Tanumihardjo (2009), antioxidants assist in protecting individuals from diseases such as cancer and tends to slow the aging process. These include lowering hypertension, urinary tract infections, skin ailments, diabetes and is good for gut health and eyesight. It contains numerous

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antioxidants which could combat various types of cancers. This means that the consumption of foods prepared with tomatoes have the potential of boosting the immune system since it contains high levels of the antioxidants, β-carotene.

Tomato is technically a fruit, because it develops from the ovary of a flowering plant and bears seeds (Mendelson, Zumajo-Cardona, & Ambrose, 2020). Botanically speaking, vegetables cover other plants like roots, leaves and stems, but when it comes to nutrition, tomatoes – along with seed cucumbers and zucchini – are categorized as vegetables. This is because they contain lower carbohydrate and sugar. A medium sized tomato provides just 22 calories, and about 5grams of total carbohydrate, with 3 as sugar and 1.5 as fibre. Tomatoes contain nutrients which are good for human growth and health benefits. Some of these nutrients are vitamins A, K, B, and C considerable amount of calcium and some valuable minerals known as chromium (Florida tomato committee, 2010-2019).

According to the Florida Tomato Committee (2010-2019), tomatoes have 10 health benefits to humans. Tomatoes are loaded with many, many health benefits. In fact, they are incredibly versatile and can be prepared in a seemingly endless number of dishes, as well as being great to alone. Tomato is a nutrient dense super food that offers benefits to a range of bodily systems (Bhowmik, Kumar, Paswan, & Srivastava, 2012). Its nutritional content support healthful skin, weight loss, and heart health. Tomatoes are now the fourth most popular fresh marked vegetable behind potatoes, lettuce, and onions. Tomatoes are packed with nutrients: Carbohydrates, proteins, fiber, water, wealth of vitamin and mineral content namely, vitamin C, A and wide array of nutrient

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and antioxidants including alpha – lipoic acid, lycopene, choline, folic acid, beta – carotene and lutein.

Tomatoes are good for your skin. Tomatoes contain a high level of lycopene, which is a substance that is used in some of the pricier facial cleansers that are available for purchase over the counter. Peel the tomatoes and then place the skin on your face with inside of the tomato touching your skin and leave the tomato on your skin for ten minutes, then wash. Tomatoes are good for your heart. Tomatoes contains vitamin B and potassium in it. They are effective in reducing cholesterol levels and lowering blood pressure. Therefore, by including tomatoes in your regular balance diet you can effectively prevent heart attacks, strokes, as well as many other heart related problems that may threaten your life.

Tomatoes helps to maintain strong bones and contain a considerable amount of calcium and vitamin K both nutrients being essential in strengthening and performing minor repair on bones, as well as bone tissue. Tomatoes provide essential antioxidants and contain high levels of vitamin A and C to neutralize harmful free radicals in the blood. Free radicals in the blood stream may lead to cellular damage. The amount of beta carotene increases.

Eating tomatoes are good for your kidneys and adding tomatoes without the seeds to your diet has been reported in some studies to reduce the risk of kidney stones (Bhowmik, Kumar, Paswan, & Srivastava, 2012). Tomatoes contain vitamin A which are good for improving vision and can prevent the development of night blindness. The vitamin A in tomatoes help to keep hair shiny and strong. Tomatoes do help repair damages caused by the effect of smoking. Eating tomatoes is not the most recent fad to help you quit

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smoking. Tomatoes contain coumaric acid and chlorogenic acid which help to protect the body from carcinogens that are produced from cigarette smoke.

Several studies reported that high levels of lycopene in tomatoes help to reduce chances of developing prostrate, colorectal and stomach cancers. Lycopene is a natural antioxidant that works effectively to slow the growth of cancerous cells. Heat is known to cause increase in lycopene and thus when tomatoes is heated, the lycopene levels increase concurrently. High levels of chromium found in tomatoes helps to keep the blood sugar levels of diabetics under control. Tomatoes help to reduce constipation. Tomatoes contain high water content and fibre so eating foods that contain lots of tomatoes may help improve hydration and support normal bowel movements. The fibre adds bulk to stool and helps to reduce constipation.

Tomatoes helps to provide folic acid to individual especially during pregnancy. Adequate folate intake is essential before and during pregnancy to protect the infants against neural tube defects. Folic acid is the synthetic form of folate and it is available as supplements. Tomatoes are a great source of naturally occurring folate.

Proximate Composition of Tomatoes

Opadotum, Adekeye, Ojukwu, and Adewumi (2016) conducted a comparative nutritional analysis of tomatoes using two different drying methods; sun drying and oven drying. The mean value of the moisture content for sample A (control), B (sundried) and C (oven dried) were 40.14 ± 0.01, 9.04 ± 0.03 and $8.67 \pm 0.01\%$ respectively. The ash content of sample A, B and C recorded a mean value of 20.19 ± 0.00, 42.75 ± 0.01 and $49.36 \pm 0.00\%$

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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 was 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 could be preserved for longer period than sun-dried sample due to a lower moisture content. This inhibited microbial activities which destroyed stored food products. The sundried sample (B) slightly retained more nutritional constituents (lipids, crude protein and carbohydrates) than the oven dried sample C.

Dishes Made from Tomatoes

Tomatoes is used to prepare several dishes including stews, soups, salads, sauces, sausage, among other.

Herring it's Nutritive value

According to Simpson, Allen, Shermanand and Edwards, (2015), herrings are healthy affordable and delicious type oily fishes that are packed with nutrients. Herring are small silver – coloured fishes primarily living near Coastal regions of the Atlantic and Pacific oceans. Herrings are particularly beneficial for its high levels of omega – 3 and this offer one of the most concentrated sources of unsaturated fatty acids.

A healthy herring has a greenish or grayish back and silvery bellies (Simpson, Allen, Sherman & Edwards, 2015). Their bodies are compressed, slender with pointed nose, large mouths, and round bellies. They measure about 45cm (18inches) long and weigh 1.1kg (2.4lb). The scales are large but loosely attached. They live up to 12 years. They often spawn from October to November

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and feed on plankton, sea creatures, small sprats, krill, copepods and other smaller fishes.

Herrings contain vitamin B – 12 (Cobalamine), Selenium, Isoleucine, Lysine, Tryptophan, Threonine, Valine, Histidine, Leucine and Protein.

Health Benefits of Herrings

Herrings are loaded with ample amounts of nutrients. They provide minerals such as Calcium, Phosphorus and Magnesium which help in maintaining bone and teeth health. These fishes are rich in omega – 3 fatty acids which promotes proper functioning of our brains. Although herrings have high levels of omega – 3 fatty acids they rather have low amounts of saturated fat that help to prevent heart related ailments by 50% lowering blood cholesterol levels.

Fish consumption promotes good blood circulation and lowers the chances of developing thrombosis. Most sea foods contain eicosapentaenoic and docosahexaenoic omega – 3 oils that help in the prevention of the production of eicosanoids which often lead to inflammation and possible blood clots. A daily intake of fish could soothe and reduce the symptoms of rheumatoid arthritis which often swells up the joints. Studies have reported that omega – 3 fat is often associated with osteoarthritis. Herrings being seafoods could prevent consumer from acquiring Osteoarthritis.

Fish when taken on a daily could help in maintain health eyes. Studies have shown that omega – 3 fatty acids prevent eyes from getting macular degeneration. Fish also has retinol which is a form of vitamin A that's helps to promote better night vision (health benefits times 2017). Herrings contain selenium, iodine, potassium and zinc. Iodine is known to be essential for the

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health of thyroid glands. Selenium on the other hand helps in the prevention of cancer (Health benefits times 2017).

Seafoods provide relief from asthmatic attacks and also protect our lungs thus high consumption of fish makes our lungs healthy and strong. Herrings contain omega – 3 which helps to prevent depression. It has been reported that low levels of omega – 3 is often associated with high risk of developing depression. It could also prevent such individuals from getting seasonal affective disorder as well as postnatal depression. Research has shown that fish consumption prevents the inflammatory bowel disease such as ulcerative Colitis and Crohn's disease. Omega – 3 also slows down the development of inflammatory bowel disease. Human brain consists of 60% of omega – 3 fatty acids thus high intake of seafood a rich source of omega-3 fatty acids could lead to lower chances of getting dementia as well as mental problems. Omega-3 fatty acids are also associated with good reading skills, concentration and behaviour.

Herrings can be used for preparing most of our Ghanaian dishes like jollof, ayoyo soup, groundnuts soup, palmnut soup and all stews. According to health benefits times (2017), herrings can be eaten by smoking, salting and picking. Also, dried herrings are often consumed in the Philippines with eggs, garlic and rice. Herring soup is considered as a traditional dish in Sweden.

Origin and Distribution of Onion

Onion (*Allium cepa (L)*) is one of the species of a large genus family (Allium). It is safe for human consumption and has more than 700 species (Bernie et al., 1999). It is believed to have originated from the region comprising Afghanistan, Iran, and the Southern portion of the former Soviet Union (Suleria, Butt, Anjum, Saeed & Khalid, 2014).

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Onion (*Allium cepa L.*) are usually part of the everyday diet for most people and a crop of enormous economic importance all over the world (Mogren, Olsen & 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. Onion can be used in diverse ways such as added fresh to already cooked food, it could be powdered, dehydrated, oil extracted, juice, salt or pickled. The unique flavour of onion often help to improve recipes.

Nutritional and Health Benefits of Onion

Consuming onions bring a lot of health benefits due to its nutritional value. According to Obeng- Ofori, Danquah and Ofosu Anim (2007), the long edible portion of the onion contains energy 31 calories, protein 1.5 g, fat 0.6g, total sugar 7.2g, other carbohydrates 0.3g, vitamin A 0, thiamin 0.04 mg; riboflavin 0.02mg; niacin, 0.1mg, vitamin C 7mg ; iron, 0.5 mg; magnesium 16.5mg; potassium, 150 mg; and sodium 7mg.

Research has found that Allium species often help to destroy and limit tumor growth, cardiovascular diseases, aging and all processes that are linked with free radicals (Stajner, Milic, Candanovic-Brunnet, Kapor, Stajner & Popovic, 2006). Onion contains Sulphur compounds which help in lowering the risk of cardiovascular disease. 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 Ozougwu (2011), the consumption of onion helps with hyperglycaemia and hyperlipemia. This implies that the more an individual consumes onion products or foods containing lots of the better onions, The rate at which a child or infant falls sick or comes up with other

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medical issues may reduce provided the parents feed the child with complementary food that has a lot of onion.

In a study of proximate composition of onion Yalcin and Kavuncuoglu (2004) reported some physio-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. The physio- chemical analysis showed that onion seeds possessed high amount of oil 21.86% - 25.86% and crude protein 15.7% - 26.1%. The 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.

Dine Tenore & Dine (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 makes them a functional food, but onion seeds contain only low concentration of these compounds. 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% carbohydrates 14.146% and 14.772%, total sugar 4.74% and 2.32%, vitamin C 6.5mg and 5.7mg, calcium 46.9 mg and 25.7 mg, phosphorous 50.6 mg and 129 mg respectively.

The level of protein 2.62% and 1.489%, fat 0.4% and 0.721%, iron 0.6mg and 0.24mg, copper 0.04mg, manganese 0.2mg and 0.4 mg are comparatively lower in the varieties. The results obtained confirmed the useful

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and utility of onion bulbs of both varieties. The results also suggested that Bangladeshi onion has adequate quantities of vitamins and minerals and has the potential to meet the nutritional requirements for human health, and thus is better than the onion of Indian origin (Shovon, Abida, Muhammed, & Ahtashom, 2013). According to Edet, Eseyin, and Aniebiet (2015), onion contains calcium, magnesium, manganese, potassium, phosphorous, sodium and iron. These minerals make onion a good source of minerals for good bone, teeth and muscle growth.

Effect of Drying on Foods

Drying is one of the oldest methods of food processing and preservation. 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 minimize the water or moisture content in food to one at which microbial spoilage and deterioration are greatly reduced (Akpinar & Bicer, 2004). Sun, oven, and solar drying are the most common types 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 (Lansasni, kounila, Mahrouz, Mohammed, & 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 do produce a more uniform, hygienic and attractive colour dried product. According to Ogunlakin *et al.* (2012), oven drying methods has a better effect on the nutritional and functional properties of cocoyam flour than when direct sun drying method is used. During the period of drying, heat is added, and

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moisture is removed from the food. Several changes take place which tend to affect the nutrient contents of food in various ways; it can either increase the concentration of some nutrients (Hassan, Umar, Maishanu, Matazu, Faruk & Sanni, 2007; Ladan, Abubakar & Lawal, 1997; Morris, Barnett & Burrows, 2004). For instance, vitamin C is often lost (Perera, 2005) and changes in colour and appearance may occur but may not be desirable (Kendall, Dipersio & Sofos, 2004). Moderate losses of B vitamins also occur during drying.

According to Baysal, Icier, Ersus and Yildiz (2003), the structural and physicochemical changes that take place affect the final product quality. According to Krokida and Maroulis (2001), the drying method and processing conditions affect significantly the colour, texture, nutritional content, density, porosity and sorption characteristics of the material so that the raw material may end up as a completely different product depending on the type of drying method used and the conditions applied. According to Sablani (2006), loss of nutrients in the dried food 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, a vitamin A precursor is obtained from plant foods. It is a bright orange pigment which is found in vegetables such as carrots, sweet potatoes and dark 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 and its main function is in the visual cycle in the retina of the eye. It also plays an important role in growth, development, reproduction and in building a good immune system (Huang, Liu, Qi, Brand, &

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Zheng, 2018). The Adequate intake (AI) for vitamin A for infants from birth to six months of age is 250 µg per day of retinol (as retinyl esters) and for infants seven to 12 months of age is 430 µg per day of retinol equivalents. The RDI for vitamin A for toddlers aged one to two years is 300 µg/day as retinol equivalents (National Health and Medical Research Council [NHMRC], 2006). An insufficient amount of vitamin A in a diet results in vitamin A deficiency (VAD) and is responsible for night blindness. Increased susceptibility to infections and impaired growth and development (Katona & Katona-Apte, 2008). Excess β-carotene is not associated with major adverse effects when it is converted to an 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 (UNICEF, 2003). Complementary feeding plays a vital role in bridging this gap. According to USDA (2009), in order to fill that nutritional gap, infants should be introduced to complementary foods (foods other than breast milk or infant formulas) after weaning at 6months after birth.

Complementary foods can be defined as food 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 the transition from milk feeding to eating foods that the rest of the takes family foods (Koletzko, Cooper, Makrides, Garza, Vauy & Wang, 2008). The target range for complementary feeding is generally taken to be from 6 to 24 months

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of age (WHO, 2003), even though breastfeeding may continue beyond two years (PAHO/WHO, 2002).

According to UNCEF (2011), complementary foods should be high in energy or energy density contain protein which has all the essential amino acids should have the required vitamins (A, C and K) and minerals (iron, folic acid, and calcium) with no anti nutritional components and at the same retaining the qualities for palatability. Complementary foods play a very important role in the development of children (Amankkwa, Barimah, Nuamah, Oldham & Nanji, 2019).

According to Codex Alimantarius Commission [CAC] (2008), complementary foods should be of appropriate nutritional quality and the amount of energy should balance that obtained from breast milk. Infants needs nutritionally balanced, caloriedense complementary food 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 the World Bank (2005), stunted growth occurs as a result of malnutrition during this period and once it occurs, it 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 for the mental growth of the infant. This is because the brain develops raptly from 5 months before birth to 10 months after birth. At the end of the first year of life, the brain should be fully developed and should have attained 70% of its adult weight (Brown & Jernigan, 2012).

Malnutrition in early childhood impairs cognitive function which may have an impact on the educational attainment of children later on in life

(Grantharm McGregor, Cheung, Cueto, Glewwe, Richter, & Strupp, 2007). Complementary foods are expected to have adequate energy density to provide a growing child with the daily energy requirement. For complementary foods the amount (gram or volume) needed to provide the required energy is 200-333 g/day for 6 to 8 months old, 300-500 g/day for 9 to 11-month-old, and 550-917 g/day for 12 to 23 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 & Sadeh, 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 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 highlighted that fat enhances the taste, texture and aroma of several foods, making them more appetising Fat together with carbohydrates supply the energy needs of infants (WHO, 2001, Monte & Giugliani, 2004). When

adequate breast milk is consumed, the amount of fat required from complementary food is 0g /day (0%) at 6- 8 months. 3g / day (5-8%) at 9-11 months, and 9- 13 g/day (15-20% at12-13 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). Oxidative rancidity tends to shorten the shelf life of complementary foods. The decrease in fat content could be an advantage to health and extend product shelf life (Saskia & Martin, 2008). According to Dietz and Robinson (2005), excessive fat intake predisposes infants to childhood obesity and subsequently cardiovascular diseases as well as increasing micronutrient malnutrition in infants (PAHO/WHO, 2002).

Dietary fibre has several health benefits during the early and future lives of a child (Brooks, Mongeau, Deeks, Lampi, & Brassard, 2006). Although crude fibre does not supply nutrients to the body, it adds bulk to food and thus facilitates bowel movements (Peristalsis) and prevents lots of gastrointestinal diseases in man (Brownlee, 2011). Brooks *et al.* (2006) indicate that it is essential for infants to be fed with complementary foods that contain adequate dietary fibre so that tastes and eating patterns become established as early as possible. Fibre should therefore be introduced gradually into the diet of infants from the age of 6 months, but they should be made to consume a very low fibre diet. High-fibre foods in effect give satiety by filling the stomach and delaying the assimilation of nutrients (Rolfes, Pinna, & Whitney, 2008).

Abeshu et al. (2006) also assert that increasing the intake of dietary fibre increases stool bulk, causes flatulence, and decreases appetite. According to

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Ijarotimi and Keshinro (2013), low crude fibre content may encourage infants to eat more nutrient dense foods that may contribute to meeting their daily energy needs and other essential nutrients requirements. Excessive dietary fibre in complementary foods may have undesirable effects such as lower calorie density and irritation of the gut mueosa (Asma, Fadil, & El Tinay, 2006). According to Amagloh and Coad (2014), 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 is an indication of the level of minerals present. Minerals play critical roles in the lives of infants and young children. The minerals help in building strong teeth and bones; help in the proper functions of muscles and nerves, blood clotting, boosts of the body's immune system and promotes proper functioning of other organs in the body (Soetan, Olaiya & Oyewole, 2010).

Solomon (2005) is of the view that, the moisture content of complementary food powders is very important as high moisture content encourages microbial growth. According to accepted procedures of American Association of Cereal Chemists (AACC), (2000), a moisture level above 14.5% encourages microbial growth causing deterioration in flour. However, Shahzadi, Butt, Rehman and Sharif (2005), reiterate that flour products with moisture content less than 13% are more secured from deterioration caused by moisture.

The 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 (Forsido, Duguma, Lema, Sturm & Hensel, 2019). 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% and fat should range from 10 to 25%. According to Mckevith (2004) 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 alternative or improvement to cereal based complementary foods in order to reduce the incidence of malnutrition among children (Adenuga, 2010).

The following are some of the results of proximate analysis conducted on complementary foods. Fikiru, Bultosa, Forsido and Temesgen (2017), formulated and analyzed 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 reported were within the standards set by (WHO/FAO, 2004). This implies that if infants are fed with such complementary food, the energy that will be obtained from the food would be enough to support the rigorous activities of the infants.

Mbaeyi-Nwaoha and Obeta (2016) formulated a complementary food from millet, pigeon pea and seedless breadfruit leaf powder blends and analyzed. The complementary food had moisture content ranging from $3.39^d \pm 0.060 – 4,78^a \pm 0.090$, protein $14.59^d \pm 0.250 - 24.27^a \pm 0580$, fat $1.21^c \pm 0.020 - 4,85^a \pm 0.305$, ash $2.51^d \pm 0.0 15 - 4.046^a \pm 0.245$ crude fiber $4.76^c \pm 0.020 - 4.85^a \pm 0.230$ and carbohydrate $54.87^a \pm 0.295 - 71.17^a \pm 0.015$, the 11.51% of fibre

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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 $8.56 \pm 0.40\%$, ash content of $1.88 \pm 0.19\%$, protein of $18.45 \pm 0.66\%$ fat of $31.22 \pm 0.95\%$, fibre $2.49 \pm 1.72\%$ (lkese, Vbwa, Adoga, Lenka, Inalegwu et al., 2016). Looking at the proximate analysis results reported, it can be seen that the carbohydrate content was below the standard set by WHO /FAO (2004) ($\geq 65\%$) but the fat content was high enough to provide the infants with the energy needed for growth and development. Lohia and Vdipi (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 $7.1 \pm 0.7\%$ ash $1.3 \pm 0.2\%$ crude fibre 3.7 ± 0.31, crude protein 10.7 ± 0.1, fat 12.0 ± 0.20, carbohydrate 68.8 ± 0.9, the malted food mix had the following recordings of moisture 4.3 ± 0.1, ash 1.2 ± 0.03, crude fibre 1.5 ± 0.01, crude protein 11.5 ± 0.2, fat 11.7 ± 0.01 and carbohydrate 71.2 ± 0.3. The proximate analysis of the two food mixes showed that the malting process increased the protein and carbohydrate content of food therefore could 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 leaves* powder. Through proximate analysis the following amounts of nutrients were recorded in the complementary food, moisture content ranged

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from $7.06^d \pm 0.01$ -7 .$51^a \pm 0.02$, protein $16.04^d \pm 0.02$- $17.59^b \pm 0.01$, fat $20.80^d \pm$ 0.01- $23.84^a \pm 0.01$, fibre $2.25^d \pm 0.02$- $4.42^a \pm 0.02$, ash $1.40^c \pm 0.01$- $2.50^b \pm$ 0.01 and carbohydrate $47.63^c \pm 0.03$- $49.32^b \pm 0.02$. 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 $46.36 \pm 0.62^a – 50.41 \pm$ 0.01 %, fat $5.09 \pm 0.01^a – 7.13 \pm 0.01$ % protein 11.17 ± 0.019 -14.21 ± 0.00%, ash 3.30 ± 0.019- 3.48 ± 0.01%. This therefore means that the moisture content of the food was 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, ginger and modified cocoyam starch. They reported a protein content of $2.68^d \pm 0.08 – 3.97^a \pm 0.08$, ash $0.23^a \pm 0.02^a – 0.57^{a.} \pm 0.01$, fibre $0.81^d \pm 0.04$-$1.11^a \pm 0.02$, fat $1.22^d \pm 0.02^d$- $1.93^a \pm 0.02$ and carbohydrate $78.55^a \pm 0.12^a$-$80.87^a \pm 0.05$. The moisture content ranged from $11.55^{ab} \pm 0.02$- $16.51^a \pm 0.03$. The moisture content of the complementary food was too high and above 14.5% as recommended by AACC, (2000) which promoted microbial growth and caused deterioration of the 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 and 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 and ash 2.0 ± 0.0g/100g dry weight. This therefore shows that the complementary foods formulated contained the necessary nutrients needed for

growth and development by infants but the β carotene content was not determined or should have been determined since orange fleshed sweet potatoes are 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-$5.15 \pm 0.08\%$, ash 2.05 ± 0.07-$2.60 \pm 0.14\%$, crude protein 13.31 ± 0.22-$35.6 \pm 1.28\%$, crude fat 15.6 ± 0.2-$38.1 \pm 0.57\%$, crude fibre 9.07 ± 0.26-$10.8 \pm 0.35\%$ and energy (Kcal) 473.9 ± 16.19-598.5 ± 14.24. Looking at the results of the analysis, the formulated food had high moisture content which may have affected 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 tend to affect the general quality of food as well as their acceptability. Functional properties establish the purpose and use of food items for various food products. Ponzio, Puppo, and Ferrero (2008) reported that functional properties of flours have also been related to 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 step (Van Hal, 2000), processing methods such as parboiling (Osundahunsi *et al.,* 2003), blanching (Jangchud, Phimolsiripol abd

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Haruthaithanasah, 2003), drying techniques (Yadav, Guha, Tharanathan, & Ramteke, 2006), and peeling, pre-treatment and drying temperaturs (Muruf, Akter Mst, & Jong-Bang, 2010a) have been found to have effect on the quality of pear millet flour produced. Some of the functional properties included water absorption capacity, oil adsorption capacity, or emulsion activity/stability. If complementary food is to be produced during 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 and Uja (2014) highlight that bulk density also assesses the heaviness of flour. It is affected by moisture content and particle size of the flour (Onimawo & Egbekun 1998). According to 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 (Adepeju, Gbadamosi, Adeniran & Omobuwajo, 2011).

Mburu, Gikonyo, Kenji and Mwasaru (2011), asserted that low bulk density is beneficial in the formulation of baby foods where high nutrient density and low bulk is desired. Akubor, Yusuf and Obilegunam (2013) reported that lower bulk densities are considered to be the best for complementary food as foods prepared from low density food items are easily digested by infants while retaining the nutrients. Research report on the bulk densities in their formulated complementary foods by Laryea (2016) found that a lower 0.787 to

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0.827 bulk density in his complementary food prepared from orange fleshed sweet potato, millet flour and soya bean flour. This implies that the flour of the ingredients had smaller particle sizes. Lohia and Udipi (2015) report 0.68± 0.01 bulk density in their malted food mix and 0.73±0.02 in fermented food mix developed from cereals and pulses. This means that malted foods produce smaller flour particles than the fermented foods.

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

Swelling Power

Swelling power is a sign of water adsorption index of granules during heating (Kusumayanti, Handayani & Santosa, 2015). Adeleke and Odedeji (2010) report that swelling power is influenced by the protein content of the food samples. Ayo-Omogie and Ogunsakin (2013) both report that swelling cause changes in the hydrodynamic proteins of food. This brings about characteristics such as body, thickening and increase in viscosity of 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 food there by enabling the child to consume more in order to

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meet his/her nutrient requirement. Laryea (2016) reported a 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 a swelling index of 129-131.75% from complementary food prepared 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-Nwaoho and Obetta (2016) recorded 2.25±0.695 to 3.16 ± 4.876 in their complementary food. Ojinnaka et al. (2013) prepared complementary food porridges from blends of soya bean flour, ginger, modified cocoyam starch and recorded a swelling power of 2.56 ± 0.05 to 3.03 ± 0.04.

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 and temperature of an aqueous suspension of starch granules continues to be disrupted (Xie, Liu, Chen, Xue, Chen, Yu & Corrigan, 2007). Water molecules become attached to the liberated hydroxyl groups and the granules increase in starch solubility, Adepeju *et al.* (2014) recorded lower solubility index, ranging from 3.27 ± 0.45 to 4.9 ± 0.26 in their breadfruit based complementary food while Laryea (2016) reported an index ranging from 17.78% to 20.32%.

Complementary Foods Developed from Pearl Millet.

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) Laryea

(2016), formulated a complementary food from flours of orange fleshed sweet potato, millet and soya bean using the drum drying method but millet was not the main ingredient. 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 (0.53mg/100g) content than the control complementary food used as control. This was maize based. Ash and fat content determined were comparable to that of a commercial complementary food.

Food Product Development

Food product development is a process of developing new food products or improving upon existing ones. It is considered a very significant procedure in the food industry (Earle, & Anderson, 2001). According to Stewart-Knox and Mitchell (2003), it is essential if the food industry needs to survive in the current competitive food market. To the food industry, the absence of product develop could lead to failure in the industry. Food industries without planned food product development or process often compete on the market based on only price which may tend to favour only industries with the lowest cost inputs or low production costs.

According to Rudder, Ainsworth and Holgate (2001), the process of food product development comprises of several stages that include ideas and concept generation, screening, research, development; sensory evaluation and

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product testing, and market launch activities. Carpenter, Lyon and Hasdell, (2000) have also reported that sensory analysis or evaluation 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 may fail. Sensory evaluation is also used to select the most preferred product out of the different formulations developed in order to meet the consumer's sensory qualities.

Sensory Evaluation

Sensory evaluation is a scientific method used to evoke measure, analyse and interpret results generated from those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing of consumers (Stone & Sidel, 2004). The characteristics of food are perceived by the five senses; taste, sound, touch, sight and smell. Sensory evaluation is important in the food industry and sensory evaluation is useful in the development of new products, product matching, product upgrading, quality control, storage stability, product grading, process modification selection of a new source of supply, cost cutback, rating, consumer acceptance and/or opinions, panellist selecting, consumer preference and training (Singh-Ackbarali & Maharaj, 2014).

There are many types of sensory evaluation methods, but the most commonly used methods are the difference tests, descriptive analysis and consumer acceptance tests (Yang & Lee, 2019). Difference tests estimate the extent of sensory differences between samples. Consumer preference, acceptance 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, the paired-comparison test and ranking tests. Sensory characteristic such as texture, colour, aroma and flavour are the powerful determinants in food acceptability. In the food industry, appearance and colour have become important criteria in terms of how they presented because they have effects on the appetite and preference of consumers. According to Spence (2015), food colour plays an essential function in driving consumers likeness and consumer acceptability of a variety of food products. However, Singh-Ackbatali and Maharaj (2014) also highlight that appearance and colour are indices of the inherent good quality of foods associated with acceptability, as they can arouse or inhibit consumer appetite and preference.

Cost Benefit Analysis

Cost benefit analysis is a procedure by which the streams of gains and losses of a proposed project (or policy or programme) are identified and measured in monetary terms so as to allow for direct comparison. These are then aggregated across individuals in a defined society to establish its net social gain or loss (Pearce, 1983:3).

According to business jargons the economics define cost analysis as the measure of the cost output relationship, the economist is concerned with determining the cost incurred in hiring the inputs and how well these can be re-arranged to increase the productivity (output) of the firm. In other words, the cost analysis is concerned with determining money value of inputs (labour, raw material), called as the overall cost of production which helps in deciding the optimum level of production. According to Universal class cost analysis is a comparison of costs. Cost used to prepare financial statements.

A cost benefit Analysis (CBA) is a common framework for evaluating the benefits and drawbacks (costs) associated with any project (Arshad, 2004). Cost Benefit Analysis is used to evaluate the opportunity to implement investment projects by predicting the cash flows of the project. In the private sector CBA's are not mandatory. However, in the public sector, CBA's are widely used for large investment project where it is necessary to prove with solid financial tools that the investment project is feasible, and that public money is not spent in vain.

The technique has the advantage that all costs and benefits are taken into account before making a decision on which alternative to select. We are living in a civilized society which demands that much more thought be given to all possible alternatives before arriving at the best solution obtainable. We cannot make decisions based on profit alone, there is need to investigate on the benefits and drawbacks associated with various projects in order to come up with an informed decision which is not only cost effective but also beneficial to the society in one way or the other, directly or indirectly (Oswald, 1984).

A simple financial CBA answers the first question. If the next two are to be answered, efficiency prices are used and an economic CBA performed. This can incorporate wider social effects and may require the use of environmental valuation techniques (van Zyl et al, 2005)

Incremental costs and benefits of the situation with a proposed project, as opposed to the counterfactual without the project, are used (Campbell & Brown, 2003:2). Benefits are classified as gains, and costs as losses, in human welfare. Benefits and costs in CBA can be measured in terms of required compensation or willingness to pay (WTP) to receive a benefit or willingness

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to accept (WTA) compensation in lieu of it. Similarly, costs can be measured as WTA compensation for a loss, or WTP to prevent it (Pearce, 1998:87). The literature on CBA has tended to focus on WTP. There has been a general preference for WTP as the more "conservative" measure, which was the recommendation by an expert panel in the USA in 1993 (Arrow et al., 1993), which served to evaluate the contingent valuation method - sometimes used for calculating WTP or WTA (OECD, 2006:164-165).

Since project costs and benefits flow over several periods of time, they are discounted to their present values (PVs). Discounting accounts for peoples' preference of the present to the future, and the social opportunity cost of capital. PVs of costs are subtracted from PVs of benefits to calculate the Net Present Value (NPV) (Pearce, 1998:87). This positive or negative NPV is used as a guide for decision-makers regarding whether the project should go ahead or not (Omura, 2004:43).

Generally, a CBA takes into account the costs involved with all alternatives and compares them to their benefits before choosing an ideal alternative to implement. According to Arshad, for the benefits that do not have a market value (that cannot be traded) such as pollution & dust, the CBA attempts to put an explicit monetary value for such. For items such as time, where a definite cost is recognized but cannot allocate a value in-terms of an actual figure, methods such as the quantifying the unquantifiable are used (this method is explained better under Data Analysis). Typically, in any CBA analysis of a scheme, researchers initially consider two to three alternatives to find the best net gain for the society and all stakeholders involved.

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Types of cost benefit analysis

Estimates this type is when one is developing and validating forecasts of costs. A fundamental step in planning a business, strategy, program or project. Lifecycle cost analysis is calculating the expected total cost of ownership of an asset over its lifespan.

Cost-Benefit Analysis is a modeling and comparing cost and benefits such as product development costs versus revenue. Typically uses estimates such as payback period and return on investment.

Efficiency is the measures of cost efficiency based based on the efficiency formula.

Cost Effectiveness is the process of comparing the costs of strategies relative to results where results aren't purely financial. For example, comparing different ways to improve your quality of life according to cost and non-financial results such as happiness.

According to Van Zyl et al, 2005 social CBA normally sets out to answer the following questions in this order.

1. Is the project is viable for the investor, i.e. does it make financial sense to the proponent?

2. If so, does it remain viable once government (e.g. taxes) and market distortions (e.g. monopoly power) are corrected for?

3. If so, does it remain viable after allowing for externalities?

Importance of cost analysis

Benefit cost analysis is a decision-making tool used to determine the feasibility of a project or investment, or the probability of its success. Benefit cost analysis allows the manager to compare the ultimate cost(s) and benefit(s)

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of a proposed business activity or investment, prior to committing time and resources. Benefit cost analysis is a systematic, quantifiable approach that exposes strengths, weaknesses, and benefits of available options that might satisfy a specific business activity.

According to Nicol and Coen (2003) argue for developing a cost-benefit analysis model for learning technology. However, there are three substantive issues with this approach. First, it is problematic because it involves comparing different things; second, because by understanding the purpose of the analysis, it may be possible to justify the necessary simplifications for special cases and limited applications while being explicit about the limitations; and third (and conversely), this can expose errors and omissions in the analysis even after accepting its general principles.

The need for cost-benefit analysis is not about ignoring distinctions of quality and value and reducing things to a monetary value. It comes from the need to make decisions. In making a decision alternative are ordered to enable selection, but these are not always equivalent to each other, which makes this problematic. Cost benefit analysis is designed to compare the costs and benefits of a project or programme. It is often used when deciding whether to implement large projects, or choosing between different options.

Cost benefit analysis helps businesses to pick through available options, rank projects according to the order of their merit, and overcomes biases for the good of the business. Cost benefit analysis is important because is used for monitoring and evaluation

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, procedures and techniques that were used in the study.
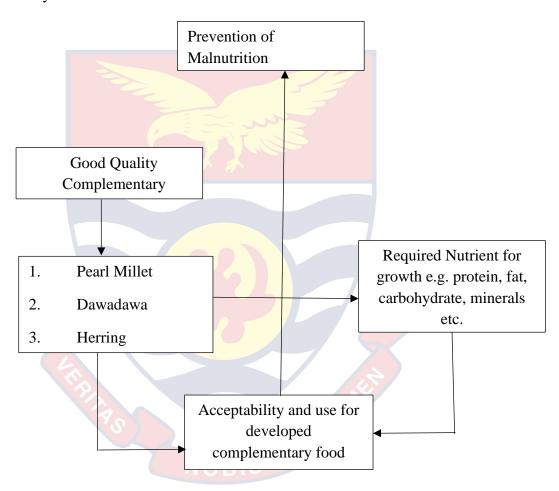
Figure 3: Conceptual framework

Source: Field data, Apolala (2020)

Research Design

The study was conducted using the experimental research design. Experimental research is the intentional manipulation of variables as determined by the researcher to see the cause and effect. The treatment or

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manipulation of the variables causes change or otherwise in the independent variable (Flannelly, Flannelly & Jankowski, 2014). In order to determine the various influence of the pearl millet, dawadawa and herrings at varying quantities in terms of their nutritional value and sensory properties (taste, appearance, aroma and texture), the formulation was manipulated to determine their effects. The design will be deemed appropriate for the study since it enabled the researcher to develop a complementary food, identify the chemical constituents of the complementary food and determined the functional characteristics of the complementary food.

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

Also, in an experimental study one can manipulate precisely one or more variables in the experiment. 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.

Study Area

The study was conducted in Damongo which is a town predominantly occupied by farmers engaged in farming activities and merchandising. It is the regional capital of the Savanna Region. It shares boundaries in the South with Central Gonja District, Bole and Sawla- Tuna- Kalba District in the West, Wa East District in the North West and North Gonja District to the North East.

Population

A population is the general group from which the researcher obtained 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 West Gonja district Damongo. For the purpose of the study, the accessible population consisted of infants from six (6) to twenty-four (24) months in Damongo West Gonja district in the Savanna Region.

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 and with the aid of their mothers selected sixty (60) infants aged from six (6) to twenty-four (24) months old for the study. The researcher used sixty (60) panellists as sample size because similar study carried out by Ashun (2017) on orange fleshed sweet

potato used fifty-six (56). According to Gacula (2006) recommended that the number of targeted consumers needed for a hedonic scaling test range from 40 to at least 100. The sampling was done at the West Gonja Hospital using babies who have been coming for post-natal care with their mothers on regular basis. The researcher requested for the attendance list of all babies that visited the hospital and used random sampling to obtain 100 babies. Out of the hundred (100) babies who regularly attended the post-natal care, the researcher picked the babies that fell between six (6) to twenty-four (24) months old. One the day of the data collection four (4) mothers opted of the study, since they were given the option to participate or otherwise opt out.

According to R. Popper (2003) there is no argument that kids have becomes one of the largest markets in many parts of the world. While it may be difficult to put a finger on any precise amount, the purchasing influence of kids has been estimated at $ 300 billion in the United States alone. Food and beverages represent as much as 60% of that impressive youth market. Small wonder that food and beverage manufactures are discover what stimulate the palates of kids and teens. He added that today's kids have more choice and are more in control of their diet than ever before. Parents, in many cases, are more than ready to do what their kids want, especially as their kids grow older.

A study by Birch (1980) provides experimental evidence for the role of peer in children's food preferences. According to Birch's research, three – to five – year – old children will change their preferences depending on what they see other children eat. Again, there is implications of peer influence for marketers as well as sensory researchers. The fact that children influence other children, even at a very young age, suggests that finding ways to leverage peer

influence can be an important element in growing the market for a new product. For example, since this study is targeting the grassroots a company might engage cool kids to champion this product.

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 (ADB, PADB, PADB, & CLM). The instrument was in one section about the four formulations to be evaluated by the infants (panelists) (Refer to Appendix).

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 for copy of ethical clearance letter). Consent forms of participation were provided to participants especially the mothers to either sign or thumb printed. The consent form was in English and Gonja language (Refer to Appendix for details).

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Materials and Methods

A

B

C

D

E

Figure 4: Materials

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Source of Raw Materials

The pearl millet variety of millet was purchased from Navrongo market and was used as the major ingredient for all the complementary food formulations. The other ingredients were herring, which was bought from Tamale market. Tomatoes (Bolga variety) and onion (red onion variety) were bought from kotokuraba market in Cape Coast. Dawadawa was purchased from Navrongo market. Commercial millet complementary food (cerelac) used as the control, was purchased from a supermarket in Tamale.

Pearl Millet Flour

Flour from the pearl millet was made using the mothed adapted in the flow chart described by Adeleke and Odedeji (2010). Pearl millet cob were selected weighed 40 kg and washed thoroughly in clean water. A calabash was used to decant the water and remove stones available in the pearl millet. The millet was washed twice, and sun dried for 4 days. The dried pearl millet was then milled into flour using an electric mill (Panasonic mixer grinder, MX-AC 2015). It was then packed into zip lock bags and further wrapped in an opaque bag to ensure it is impermeable as suggested by van Hal (2000). The packed flour was than stored in a freezer for use later.

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Pearl Millet

↓

Sorting /grading

↓

Removal of stones with calabash

↓

Wash the pearl millet

↓

Draining the pearl millet

↓

Sun dry for four days

↓

Dry milling

↓

Packaging
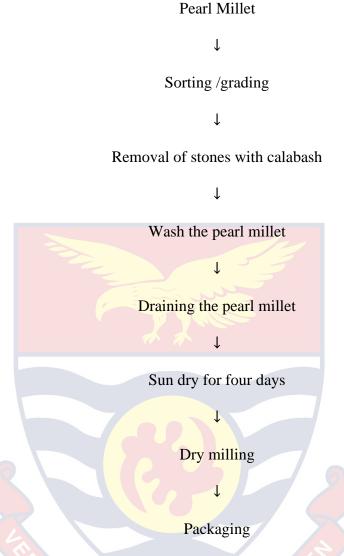
Figure 5: A flow chart showing the processing of Pearl Millet Flour. Adapted

from Adeleke & Odedeji (2010)

Onion Powder

The flow chart below shows the process for the production of onion

powder. The fresh onions were selected and 6kg weighed into a bowl. The

onions were then peeled, washed and chopped into very small pieces using the

nicer dicer manual chopping machine. The chopped onion was spread thinly on

a drying tray and dried in a hot air oven (Memmert model100-800) at a

temperature of 50^0C for three (3) days (continuous). The dried onion was milled

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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 use later.

Weighed onion

↓

Peeled and wash

↓

Chopped

↓

Blend the onion

↓

Spreading in a hot oven

↓

Milling the onion

↓

Sieving (0.2mm)

↓

Packaging and store in the fridge.
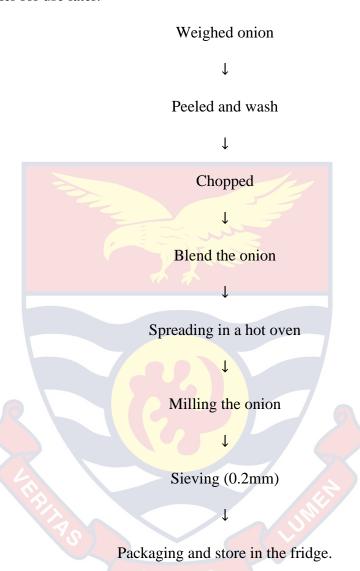
Figure 6: A flow chart showing the production of onion powder. Adapted

from Ashby (2012).

Tomato Powder

The flow chart shows the process for the production of tomato powder. The process was adapted from the method described by Ashby (2012) as cited in Osae, (2014). Twenty (20) kilograms of fresh and wholesome Bolga tomatoes was weighed into a bowl and washed. After washing, the clean tomatoes were

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blanched in boiling water for 3 minutes. The skin on the blanched tomatoes was removed and the seeds removed. After removing the seeds, the tomatoes were cut into quarters with a sharp knife. The quarters of tomatoes were spread thinly on a drying tray and dried in a hot air oven (Memmert model100-800) at a temperature of 50 ^{0}C for 3 days. The dried tomatoes were milled into powder using an electric mill (Panasonic mixer grinder, MX-AC 2015). The milled flour was sifted using a fine sieve and packed into zip lock bags. The packed tomato flour was placed in the freezer for use later.

Tomatoes

↓

Washing of tomatoes

↓

Blanched in boiling water

↓

Deskinned and deseeded and cut with knife

↓

Spread in a tray and dried in a hot air oven

↓

Milling and sieving

↓

Packaging and storage
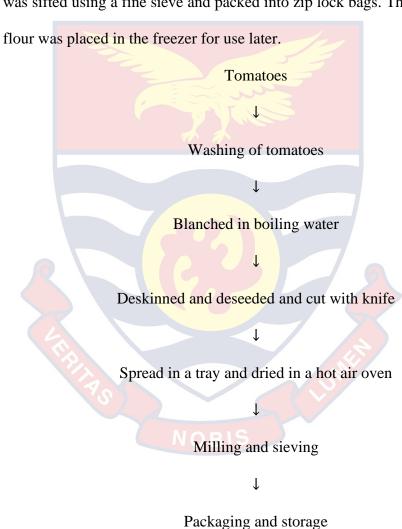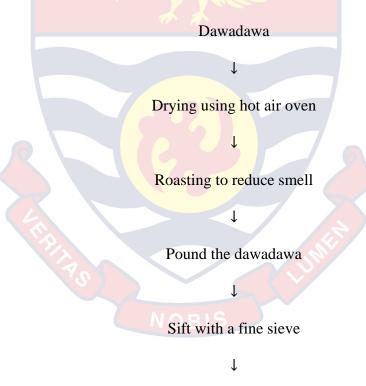
Figure 7: Flow chart showing the production of Dried Tomatoes powder as adapted from Adeleke (2010)

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Dawadawa Powder

The flow chart shows the process for the production of dawadawa powder adapted from the method described by Adeleke (2010). Twenty (20) kilograms of fresh dawadawa was weighed and dreid in the sun or oven dry. The dried dawadawa was then roasted using a drying tray placed in a hot air oven. This help to remove some of the smell. After reducing the smell, the dried and roasted dawadawa was pounded in a wooden mortar into a fine powder using a wooden pestle. The flour sifted using a fine sieve and packed into a zip lock bag. The packed dawadawa was placed into the freezer and stored for use later.

Dawadawa

↓

Drying using hot air oven

↓

Roasting to reduce smell

↓

Pound the dawadawa

↓

Sift with a fine sieve

↓

Packaging and stored in the freezer

Figure 8: A flow diagram showing the production of dawadawa a powder. Adapted from Adeleke, (2010).

Herring Powder

The flow chart shows the process for the production of the herring powder. This was adapted from the method described by Adeleke, (2010). Twenty (20) kilograms of herring was weighted into a bowl and cleaned by removing the skin. The cleaned herrings were then washed and dried in the sun for three days. The dried herrings were pounded in a wooden mortar using a wooden pestle. The pounded herrings were sifted using a fine sieve and packed into a zip lock bag. The packed herring powder was place in the freezer and stored for use later.

Herring

↓

Unskinned the herring

↓

Washing of herring

↓

Sun drying

↓

Pound with mortar and pestle

↓

Sift with fine sieve

↓

Packaging and Storage
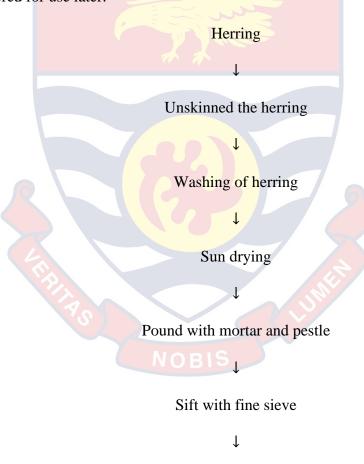
Figure 9: A flow diagram showing the production of dried herring powder.

Adapted from Adeleke (2010)

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Chemical Analysis of Samples and Formulated Complementary Food

Proximate analysis was conducted to determine the individual chemical constituents in all the formulated complementary baby foods. The methods described by AOAC (2000). Triplicate samples were used for the determinations. Carried out in the school of Agriculture laboratory of the University of Cape Coast.

Determination of Moisture Content

Porclain crucibles were washed, dried and weighed. About 10-12g of the fresh samples were weighed into clean oven dried crucibles. Filled crucibles were spread over the base of a thermostatically controlled oven at 105°c for 48 hours. This ensured equal distribution of heat to the samples. After the 48 hours the heated samples were removed from the oven and quickly transferred into a desiccator. This prevented any moisture from entering the sample. Samples were then removed and quickly weighed three times or in triplicates. The moisture content was then calculated as a percentage water loss by the sample.

$$\% \text{ moisture} = \frac{W2 - W3}{W2 - W1} \times 100 \rightarrow \text{Equation A}$$

Where: W1 = Weight of crucible

W2 = Weight of crucible + fresh grated sample

W3 = Weight of crucible + Dry samples

Determination of Ash Content

Ash content of material represent inorganic residue lift 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 AAF1100) at 105 ºC for about an hour

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and then transferred to furnace at a temperature of 550 ºC overnight, the heating continued until all the carbon particles were burn away. The ash in the crucible was removed from the furnace and placed in a dessicator, allowing it to cool, after which it weighed. The ash was then calculated using the formula below.

% Ash = $\underline{W3- W1}$ x 100   → Equation B

        W2- W1

Where:

W1 = Weight of crucible,

W2 = Weight of crucible + fresh grated sample,

W3 = Weight of crucible + Ash

Determination of Fat

The Soxhlet extraction method was used for this study. About 10- 12g of the milled samples were weighed into a 50 ×10mm soxhlet extraction thimble. This was transferred to a 50ml capacity soxhlet extractor. A clean dry 250ml round bottom flask was accurately weighed and then 150ml 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 ºC for 2 hours. The round bottom flask was removed, cooled in a desiccator and weighed. The percentage fat/oil was calculated as followed.

Calculation

Crude Fat (%) = $\dfrac{W\,2 - W1 \times 100}{W3}$,   → Equation C

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Where:

W1 = Weight of empty flask

W2 = Weight of flask + fat

W3 = Weight of samples taken

Carbohydrate Determination

Glucose solution

For preparation of stock solution, 1ml is equivalent to 0.25mg glucose, 0.250g D-glucose (dried in a vacuum oven at 70 ºC oven P_2O_5) was dissolved in water and diluted to 1litre.Working standards: a range from 0 – 20ml stock solution was pipetted into 50 ml flasks such that 2 ml of each standard gives a range from 0- 0.20mg glucose and diluted to the requisite volume.

Anthrone Reagent

About 760 ml of concentrated H_2SO_4 was added to 330ml water in a boiling flask and kept cool while mixing. One (1g) anthrone, 1g of thiourea were added to the solution and dissolve using a magnetic stirrer. The mixture was transferred into a dark bottle and left to stand for 2hours before used. It was then stored at + $1^{º}C$.

Extraction Procedure

Fifty milligram (50mg) of the milled sample was weighed into a 50ml conical flask, 30ml of distilled water was added and a glass bubble placed in the neck to help simmer gently on a hot plate for 2 hours. Water was added to top up to 30ml periodically and allowed to cool slightly, then filtered through a No.44 Whatman paper into a 50ml volumetric flask then diluted to volume after cooling. The extract was prepared shortly before colour development. A blank was prepared by taking it through the same procedure.

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Colour Development

Two militre (2ml) of each standard was pipetted into a set of boiling tubes. Subsequently, 2ml of the extract and water as the blank were also pipetted into boiling tubes. Standards and samples were treated the same way. Ten (10ml) of anthrone solution was added rapidly and mixed then the tubes were immersed in running tap water. The tubes were placed in a beaker of boiling water in a dark fume cupboard and boiled for 10minutes.

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 drawn from the standards and used to obtain mg glucose in the sample aliquot. The blank determination was treated same way and subtraction done where necessary.

Soluble carbohydrates $(\%) = \dfrac{C \ (mg) \times extract \ volume \ (ml)}{10 \times aliquot \ (ml) \times sample \ wt \ (g)}$ → Equation D

Where C = carbohydrate concentration from the calibration graph

Determination of Crude Protein

Protein present in food is calculated from nitrogen concentration of the food. The Kjeldahl apparatus was used to determine the crude protein content. The method was in steps: digestion, neutralization or distillation and titration.

Digestion

About 0.2g of the sample was weighed into a 100 ml Kjeldahl flask. 4.4mL of the digestion reagent was added and the mixture digested at 360ºC for two hours. A blank made up of the digestion mixture without any sample was prepared and in the same way. After the digestion, the digests were transferred

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quantitatively into 50ml volumetric flasks and made up to the volume by adding distilled water.

Distillation

A steam distillation apparatus was set up and 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 and 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 (10mL) of alkali mixture was added to commence distillation immediately and about 50mL 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 were used to calculate the nitrogen and hence the protein content. The conversion factor used was 6.25.

$$\%\text{Total Nitrogen (\%N)} = \frac{(\text{Sample titre value} - \text{Blank titre value}) \times 0.1 \times 0.01401 \times 100}{sample\ weight\ X\ 10} \rightarrow$$

Equation E

% Protein = %N x 6.25

Determination of Crude Fibre

Reagents

Sodium hydroxide, 1.25%

To prepare 1.25% NaOH, 12.5g of NaoH was weighed into a 1000ml volumetric flask a 700ml distilled water added and diluted to volume.

To prepare 1.25% Sulphuric acid, 12.5g concentrated. Sulphuric acid was measured into a volumetric flask containing 400ml distilled water and diluted to volume.

Procedure

Crude fibre is the organic residue which remains after the food sample has been treated under standardized conditions with standard boiled acid and alkali solution About 2g of the sample was weighed into a boiling flask, 100ml 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 100ml of the 1.25% NaoH solution was added and boiled for 30mins.Filtration continued after the boiling and the residue washed with boiling water and methanol. The crucible was dried in an oven at 105ºC overnight and weighed. The crucible was placed in a furnace at 500ºC for about 4 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.

Calculation

$$\% \text{ Crude fibre} = \frac{\text{weight of sample before ashing} - \text{weight of sample after ashing}}{\text{Sample of weight}} \times 100$$

→ Equation F

Source: AOAC (2005)

Determination of ß-Carotene

The β-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 milliliters (20 ml) of petroleum ether was put in a separation funnel after which acetone was added. Two hundred milliliters (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 petroleum ether, it was then washed 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 450 nm and the total carotenoid concentration using the coefficient of absorption for β-carotene with the following formula:

$$X(\mu g) = \frac{A x Y(ml) x 10^6}{A_{1cm}^{1\%} \times 100} \quad \rightarrow \text{Equation G}$$

$$X(\frac{\mu g}{g}) = \frac{X(\mu g)}{weight\ of\ sample\ (g)}$$

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Where:

X = is the weight or concentration of the carotenoid

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

$A_{1cm}^{1\%}$ = is the absorption coefficient of ß-carotene in petroleum ether.

Formulation of Complementary Food

The developed complementary foods will be coded ADB, PADB and APDB as presented in the Table 2. 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 formula ADB was up of 100 g of pearl millet flour, 30 g of herring powder, 35g of dawadawa powder, 15g of tomato powder and 20g of onion powder were weight and mixed together to form ADB. The PADB formulation was made up 120g pearl millet flour, 25g dawadawa powder, 20g herring powder, 20 g onion powder and 15g tomato powder. APDB sample contained 85g of pearl millet flour, 55g of dawadawa powder, 25g of herring powder, 20g of onion powder and 15g of tomato powder.

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Table 2: Compositions of Formulations

Ingredients	ADB (200g)	PADB (200g)	APDB (200g)
Pearl millet flour	100g	120g	85g
Dawadawa powder	35g	25g	55g
Herring powder	30g	20g	25g
Onion powder	20g	20g	20g
Tomato powder	15g	15g	15g

Source: Field Data, (2020)

Determination of Functional Properties of the Flour Samples

Function properties are those properties are those properties that determine the behavior 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 of determining swelling power index as used in the determination of the swelling index has been applied in this study (Kusumayanti, Handayani & Santosa, 2015). 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 cylinder 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:

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Swelling index = <u>Change in volume of sample</u>   → Equation F

Original weight of sample

Determination of Solubility

The method for determining solubility index according to Yousf, Nazir, Salim, Ahsan, and Sirwal (2017) has been used. Two and a half grams of sample was measured into a 50 ml centrifuge tube. Thirty (30 ml) millilitres of water was added and vigorously mixed, the mixture was incubated in a water bath at 30 ℃ for 30 minutes and centrifuged at 2200 rpm for 15 minutes. The supernatant was collected in pre-weighed petri dish and the residue was weighed after oven drying overnight at 105 ℃, in order to calculate the solubility. The solubility as calculated as follows:

Solubility index = $\frac{Weight\ of\ soluble\ sample}{Weight\ of\ sample\ dry\ basis} \times 100$ →Equation I

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 ten (10) times from height of 5 cm. The volume of the sample was recorded. The bulk density was calculated as;

Bulk Density = $\frac{weight\ of\ the\ sample}{volume\ of\ the\ sample\ after\ tapping\ (ml)}$ → Equation J

Determination of Water Absorption Capacity

The method described by Adebowale, Sanni and Awonorin (2005) will be adopted for the determination of water absorption capacity. Two (2) grams of the sample will be weighed into a graduated centrifuge tube. Twenty (20) ml of distilled water will be added and tube shaken for 5 minutes to obtain

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dispersion. The resulting dispersion will then be centrifuged at 3500 rpm for 30 minutes. The volume of supernatant (free water) will be measured while the sediment and centrifuge tube will be weighed. The water absorption capacity of sample will then be calculated per weight of initial dry sample.

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

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

Pearl millet baby food (control sample)

The ready to serve millet baby food (cerelac) was heated gas burn for about five minutes and poured into a labelled food warmer ready for sensory evaluation.
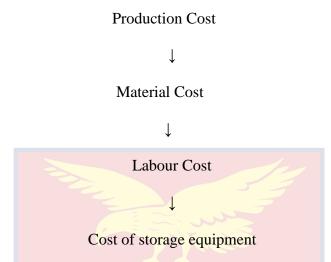
Preparation of Pearl Millet Complementary Food for Sensory Evaluation

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. A pinch of salt was added to taste. The food samples were kept in labelled food warmers ready for the sensory evaluation.

Benefit cost analysis provides method that allows management to evaluate qualitative argument using quantitative data that supports the analysis.

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All options are compared using the same method, which makes rejection of certain weak or impractical alternatives obvious.

Classification of Production Cost

Production Cost

↓

Material Cost

↓

Labour Cost

↓

Cost of storage equipment

The cost of material (raw) was calculated alongside the labour cost and the cost of storage equipment. The cost of materials includes not only the direct cost of the material items, but also any other costs that may be obtained. The cost of pearl millet, dawadawa, herring, onion and tomatoes. The following calculation was done as in Table 3.

Table 3: Cost of Production

Raw materials	Amount GH₵
Pearl millet	GH₵ 6
Herring	GH₵ 20
Dawadawa	GH₵ 10
Tomatoes	GH₵ 20
Onion	GH₵ 15
Other cost	
Cost of drying	GH₵25
Cost of storage containers	GH₵10
Grant total	GH₵106

Source: Field data, Apolala (2020)

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The cost of the above local food ingredients gave the researcher 600kg of ADB, 800kg of PADB and 600kg APDB. When you break the above kilograms into 200kg that is same grams as CLM (control) you will have ten (10) of the 200kg tins. Hence when you divide GH₵106 by ten (10) tins you will have each of the tins costing GH₵10.60 which is very cheap compared to the CLM (control) I bought at GH₵16 in West Gonja Damongo.

The GH₵ 10.60 to the researcher is still very expensive because if the local food items were bought in bulk like in bags and baskets it would've been cheaper and if an industry picks up this idea and is going to produce it in large quantity it would be as well very cheap than I have it. Also, if mothers are taken through training to produce on daily basis where the tomatoes and onion is not going to be dry in an oven it will equally be very cheap but just that it can't be stored as long as the dry ingredients will.

Data Collection Procedure

An introductory letter was sought to introduce the investigator to the Institutional Review Board (IRB) of University of Cape Coast in relations to data collection for the study (refer to Appendix for details). Permission was also sought from the West Gonja Hospital management to use the hospital premises for the data collection (Refer to Appendix for details).

The sensory analysis was conducted at the West Gonja Hospital (post-natal section). The selected panelists (mothers with babies from age 6-24 old) were seated on individual tables and were trained on how to help their babies (panelists) taste the formulation; rinse their mouths before tasting the next formulations and evaluate the other attributes. Consent forms were given to the panelists and were sign or thumb printed. The complementary food samples

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were coded with the acronym; ADB, PADB, APDB &CLM to hide the true identity of the formulations. Each panelist was given a serving plate, 4 spoons and a cup of water to rinse their mouths 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 with the help of their mother.

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 panelist frowns the face could mean the formulation was not liked while a smiling face could mean the formulation is liked. The mothers of the panelists assisted them in scoring the other attributes (appearance, texture, aroma and overall acceptability). Sensory assistants were available to help panelists who could not read and write.

Data Processing and Analysis

In analyzing the objectives, statistical software called Statistical Package for Social Scientist software for windows vision 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 a 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. The objective five would be analyse manual where the cost of production will be divided by the number of 200kg tin.

CHAPTER FOUR

RESULTS AND DISCUSSION

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

Objective One: Development of complementary food from pearl millet.

The complementary food was formulated from a combination of different proportions of pearl millet flour, dawadawa powder, herring powder, tomato powder and onion powder. The individual flour was analysed at the school of Agricultural laboratory, University of Cape Coast. The proximate composition (moisture, ash, proteins, fat, fibre and Carbohydrate) of the individual flour used in formulating the complementary food are presented in figure 10.

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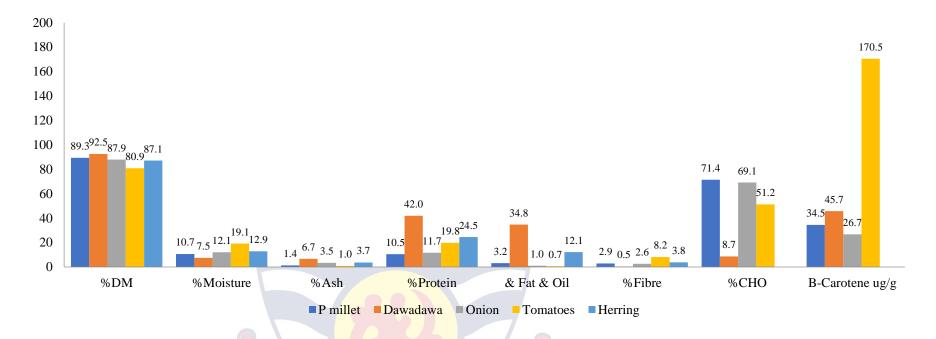
Figure 10: Proximate component of ingredients used

Source: Field data, Apolala (2020)

PMF- Pearl millet flour

A = Pearl Millet b = dawadawa   c = onion   d = tomatoes   e = Herring

Results from the study showed that herring used in the formulation had the highest protein value of 27. 19% amongst the other ingredients. The proximate analysis in figure 10 also revealed that protein was the nutrient identified in the highest amount in dawadawa powder. This was followed by carbohydrates, fat and Oil, fibre, moisture and ash respectively. However, tomato and onion powder when analysed had 19.82% and 11.65% of protein respectively. The protein content of the pearl millet flour (PMF) was found to be rather low (3.15) probably because it is a cereal which is known to be rich in carbohydrates.

The PMF (Pearl millet flour) had high (71.41) carbohydrate content. The high level of carbohydrates in the pearl millet was expected because it is a cereal or grain. Complementary foods are also expected to be energy dense (Abeshu, Lelisa & General, 2016), this makes pearl millet (PM) flour a suitable ingredient for developing complementary foods. The percentage carbohydrates (71.41%) reported in this study was lower than that reported earlier by Laryea (2016); and Danby & Bovell- Benjamin (2003), which were 83.29% and 90.6% respectively. The difference in the carbohydrates content may be due to the different ingredients used. In this study, pearl millet was used and in Laryea's study, sweet potatoes were used as the main ingredient for providing carbohydrates thus energy.

Percentage moisture recorded was higher (19.13%) as shown in figure 1 with respect to tomato powder. This was not surprising because tomato is a fleshy vegetable known to contain high water content. Herring powder had 15.00%, onion powder had 12.11% moisture whiles pearl millet 10.68%. The least moisture content of 7.48% was found in dawadawa for this study.

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Fibre was highest in the tomato powder (8.19%) followed by herring flour (3.19%) pearl millet flour (2.19%) and onion powder (2.63%). The least amount of fibre 0.45% was found in dawadawa powder which was slightly lower than that reported by Edusei, Aseidu, Sakyi-Dawson and Owusu (2004) in a similar study using dawadawa. Opadotun, Adekeye, Ojukwu and Adewumi (2016) report of lower fibre content in tomatoes dried by the sun and by oven drying. The sun-dried tomatoes recorded 0.21% whiles the oven dried 0.28%. The slight difference in fibre could be due to the difference in the methods used in drying or the variety of tomatoes used.

The fat content of the dawadawa powder as shown in figure 1 was the highest 34.77%. This was subsequently followed by the herring powder which had 1.00%, pearl millet flour was 3.15% and that of tomatoes was 1.65%. The least amount of fat 1.00% was found in onion powder. The value was similar to that reported for the other varieties of onion bulbs obtained from different origins (Shovon, Abida, Muhammad & Muhammed, 2013). From the results pearl millet, like other cereals or grains 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, Oke, Babarinde and Kunbosun (2012).

Ash content is considered very important as it gives a measure of the total mineral content of the food Sample (Shovon, Abida, Muhammad &Muhammad 2013). In this study, ash content was quite low; however, the dawadawa powder had the highest percentage (6.68%) of ash. Herring had ash value of 3.5%, onion powder had ash value of 3.46% and that of pearl millet ash value 1.35%. The least recorded ash was tomatoes with 0.99%.

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The proximate analysis showed that the ingredients used in formulating the complementary food contained moderate amount of nutrients. The protein, fat and ash content of the dawadawa and herring were good enough to serve as an excellent source of high biological protein needed for the growth of babies. Hence blending pearl millet flour as an energy food with tomato rich in moisture, B-carotene and fibre, and onion would make a nutritionally good complementary food suitable for weaning infants.

Objective Two: Examine the Chemical Constituents of the complementary food established.

The chemical constituent's fat, fibre, ash, protein, moisture, carbohydrates & B-carotene) of the formulated complementary food are presented in Table 4.

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Table 4: Chemical constituents of formulations

Sample	%DM	%Moisture	%Ash	%Protein	%Fat and Oil	%Fibre	%CHO	β-Carotene ug/g
ADB	88.62	11.38	3.68	27.05	10.09	5.42	42.37	112.39
	±0.10	±0.10	±0.16	±0.09	±0.00	±0.56	±0.20	±0.33
PADB	88.61	11.39	3.35	22.48	8.55	5.93	48.31	108.79
	±0.20	±0.20	±0.13	±0.46	±0.9	±0.39	±	±0.85
APDB	88.92	11.08	4.26	27.19	14.08	5.58	37.79	106.77
	±0.28	±0.28	±0.13	±0.60	±0.5	±0.42	±0.93	±0.38

Source: Field data, Apolala (2020)

1. Values are averages of triplicate determinations

2. Data is represented as mean ± standard deviation

3. Sample ratios are represented as (pearl millet: dawadawa: herring: tomato: onion)

4. Values in same column with same superscripts are significantly different at 95% confidence level
5. The moisture content of the flour could be an indication of its shelf life, or long it could be stored.

From the moisture content analysis shown in Table 3 PADB had the highest percentage of moisture followed by ADB and APDB respectively.

The results indicate that PADB could be stored for the longest period of time 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 the three formulations (ADB, PADB and APDB) were greater than the recommended moisture content in complementary food of 5% and 10% (Forsido, Duguma, Lema, Sturm & Hensel, 2019). Similarly, Ojinnaka, Ebinyasi, Ihemeje and Okorie (2013) record high moisture content of $11.55^{ab} \pm 0.20$ to $16.51 \pm 0.03\%$ in a soya bean cocoyam complementary food they prepared. On the contrary, Mbaeyi- Nwaoha and Obetta, (2016) recorded a lower moisture content ranging from $3.39^{d} \pm 0.060$ - $4.78a \pm 0.090$ in their millet, pigeon pearl and seedless breadfruit leaf powder blends. Although, the moisture content was higher in this study, it was below the 14.5% level recommended by ACCRA (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 onion and tomato used, and the drying technique also used.

With high Ash content of the complementary food analysed, the products may have high minerals content. These values varied among all the three (3) Formulations (ADB, APDB&PADB). APDB had the highest percentage of ash followed by ADB and the least ash percentage was found in PADB. The high percentage of ash found in APDB was rather unexpected as

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the PADB formulation contained a higher proportion of herring powder compared to APDB. This could be attributed to the fact that the more the pearl millet in a formulation the less ash it contains and vice versa.

The ash content observed in this study was higher than that which has been reported by other authors Nandutu and Howell (2009), reported the following 3.2 ± 0.8 and 2.0 ± 0.0 for recipe A and B of similar formulations respectively and Ojinnaka et al. (2013) also reported these figures 0.23 ± 0.02 to 0.01% for blends of soybean flour, ginger and modified coco yam starch in a baby formula.

Minerals play critical roles in the lives of infants and young children (Soetan, Olaiya & Oyewole, 2010). They help in building strong teeth and bones, and also in the functioning of muscles and nerves, prevent blood clotting, and promotes boosting the body's immune system. Finally, minerals promote proper functioning of other organs in the body. The ash content in all the three (3) Formulations ADB, ADB PADB &PADB in this study had mineral contents that were above the recommended value by the World Health Organization and Food and Agricultural Organization of the United Nations (WHO/ FAO) (2004) and Forsido, *et al*. (2019) which was <5g/100g.

Protein is one of the most essential macro-nutrients required in complementary foods and is necessary for rapid growth and development of an infant. The protein content of the formulated complementary food products (ADB, APDB &PADB) varied. Clearly, the protein content for APDB was more as compared with the other two formulations as shown in Table 3. The high protein content of APDB 22.48% more than ADB and PADB is significant and worthy of note. APDB a high percentage of protein was expected as the

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formulation contained more dawadawa powder know to contain high levels of protein.

The percentages of protein recorded for the complementary food formulations in this study were higher than the protein found in a similar study reported by Amagloh, Hardacre, Mutakumira, Weber, Brough and Cood (2014), who found protein in the range of 12.1% -15% for a sweet potato based complementary food. It could be due to the different food items used or the different ratio proportions of the ingredients. Nandutu and Howell (2009) also reported a protein content of 20.4 ± 0.1% and 28.0 ± 0.4% in two complementary foods they developed.

The difference in protein percentages may be attributed to the ingredients used in the formulations of the complementary foods. Every complementary food should contain about 20% Protein (Forsido, *et al.,* 2019). Looking at the results in the Table, all the 3 formulations (ADB, APDB & PADB) had protein percentages higher than the recommended value of 20%. In reference to a study reported by Bonsi et al. (2014), protein content found in a complementary food was far below what was recorded in all the three (3) Formulated samples (ADB, PADB & PADB) that were considered in this study. This makes the developed complementary food in this 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 their development.

According to the World Bank (2005), malnutrition in infants is difficult to reverse after two years of age. Therefore, the period of introducing babies to

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complementary food to babies is considered as a critical stage in their life (WHO, 2003). This period of malnutrition can lead to stunting, wasting, anemia, underweight and Kwashiorkor. Thus, complementary foods introduced to infants should be 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 impacts educational attainment of children later in life. This could also result in reduced capacity for physical work.

PADB which had the highest proportion of pearl millet flour and was found to have the highest percentage of carbohydrates as expected. This was followed by ADB and APDB respectively. The carbohydrates content increased with increasing amount of pearl millet in the formulations. This can also be attributed to the fact that; the pearl millet is a cereal and a rich source of carbohydrates. This finding is in line with that of other studies reported by Onoja, Akubor, Gernar and Chinmma (2014). The 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 $37.40 \pm 1.72\%$ of carbohydrates in wheat and groundnut complementary food.

Carbohydrate plays a very important role in complementary foods since these foods are supposed to be energy dense in order to supply enough energy required by infants to carry out their rigorous crawling activities and numerous biochemical reactions. Other studies by Nandutu and Howell (2009) report $66.o \pm 0.2$, $58 \pm 1.4\%$ and Ojinnaka et al. (2013) recorded higher carbohydrates 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) formulation of the complementary foods in this study had

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carbohydrates content lower than that recommended by WHO /FAO (2004) and PAG (1971) for complementary food ($\geq 652 / 100g$). Findings in this study show that, increasing the pearl millet flour content of the formulated complementary food could improve their carbohydrate content.

The figures (78.55[a] - 80.87 $\pm$ 0.50) reported by Ojinnaka et al (2013) were far above the suggested figures prescribed by WHO/FAO (2004) and PAG (1971). Intake of too much carbohydrates from complementary foods could have negative health implication for infants since excess fat might be deposited in the body. Deficiency of carbohydrates in the body can cause the body to convert proteins and body fat to energy, thus leading to lessening of body tissues (El-Zayat, Sibaii & El-Shamy, 2019).

Fibre content of PADB was the highest value, followed by APDB and the least was ADB. The high content of fibre in PADB could be attributed to the high amount of pearl millet flour used in the formulation. All the formulations ADB, PADB and APDB in this study contain nutrients above the recommended levels by of the WHO/FAO (2004). They suggest that the daily recommended allowance in complementary foods should be <5%. What could have accounted for the high fibre content in the formulation may be the variety of food items used, the geographical location and origin of the food items. Although, the fibre content exceeded the maximum allowable amount recommended by WHO/ FAO. This may not necessarily affect the consumers negatively since the fibre is soluble and could aid digestion. A similar study by Shiriki, Igyor and Gernah (2015), observed a fibre percentage of 2.25[d] $\pm$ 0.02- 4.42[a] $\pm$ 0.02 in some complementary foods prepared from maize, soya bean and peanut fortified with moringa and Oleifera leaf powder. Low crude fibre content

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may also encourage infants to eat more nutrient dense food that may contribute to meeting their daily energy needs and other important nutrient (s) requirement (Ijarotimi & Keshinro, 2013).

Solomon (2005) reported a high percentage fibre in a complementary food prepared from cereals and legumes. The fibre ranged from $4.76^c \pm 0.35$-$11.51^a \pm 0.230$ for millet, pigeon pearl and seedless breadfruit leaf powder blends. Although crude fibre does not supply nutrients to the body, it adds bulk to food to facilitate bowel movements (peristalsis) and help prevent lots of gastrointestinal diseases from occurring in human (El-Zayat, Sibaii & El-Shamy, 2019). Abeshu et al. (2016) reported that increasing the intake of dietary fibre tend to increase stool bulk and causes flatulence and decreases appetite. High fibre foods give satiety by filling the stomach and delaying the assimilation of nutrients. Thus, low fibre foods may be more suitable for preparing complementary foods (Rolfes, Pinna & Whitney 2008). Asma, EI Fadi I & El Tinay (2006) reported that excessive dietary fibre used in complementary foods may have undesirable effects such as lower caloric density and irritation to the gut mucosa.

Fat is a vital part of all living cells and is crucial for maintaining good health. The fat content of the formulated complementary food samples were low as shown in Table 3. However, the highest percentage of fat was found in APDB which contained low proportion of pearl millet. This was followed by ADB and PADB having the lowest percentage of fat. The results showed that the fat content increased with decreasing quantities of the pearl millet flour added to the formulation.

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For other studies the percentage fat were reported to be 4.8%-6.4% (Bonsi et al., 2014) and 2.0 ± 0.1 -3.4 ± 0.5 (Nandutu & Howell, 2009). The fat content in the above two (2) reports were lower than that in the present study. The present study found a fat content less than the daily recommended fat content for complementary foods, which ranges between 10% and 20% (WHO/FAO 2004).

Fats enhance the smell, texture and taste of several foods, making them more appetising (Mitchell 2011). Solomon (2005) reported rather high percentages 15.6 ± 0.2-38.1 ± 0.57 of fat in a complementary food. It is important to note that the amount of fat added to any formulated complementary food can affect its shelf life. Probably, because high fat content in foods tend to undergo oxidative deterioration to produce rancidification. Rancidity exposes the food to spoilage faster than one with a lower fat content.

The amount of energy a gram of fat provides is more than twice of what a gram of carbohydrate produces. Fats provide the body with linoleic acid, and other important fatty acids required for the proper growth in children. It also prevents excessive skin dryness and flaking.

Fats improves the texture of foods, aroma or flavour as well as creates satiety because it slows down digestion. Fat aids the absorption of fat-soluble vitamins such as A, D, E and K PAHO &WHO 2001. Saskia and Martin (2008) reported that a decrease in fat content could be an advantage to the health and also extend the shelf life of product. Others have reported that a higher fat content in food is a nutritional advantage because it can increase the energy content of food (Lohia &Udipi, 2015). PAHO and WHO (2002) have reported that the presence of excessive fat in diet may increase micronutrient

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malnutrition in infants. Dietz and Robinson (2005) also reported that excessive fat intake predisposes infants to childhood obesity and subsequently increases their risk to cardiovascular diseases later on in life.

The β carotene content of the formulated complementary food samples was high in ADB followed by PADB and APDB respectively. The higher content of β-carotene in ADB could be attributed to the high amount of tomato flour added to the formulation. Tomato flour contains high levels of β-carotene. According to Mitchell (2011) β- carotene is converted to vitamins A as and when it is needed by the body. It plays an essential 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 suggested daily allowance for vitamin A required by infants between 6 months to 3 years is between 350 and 400 µg in a day. All the three (3) formulation ADB, PADB and APDB complementary food samples contained appreciable amounts of β-carotene but the levels were below the range suggested for daily allowance for vitamin A in infants.

Table 5: Chemical composition of formulated complementary foods

Sample	%DM	%Moisture	%Ash	%Protein	%Fat and Oil	%Fibre	%CHO	β-Carotene μg/g
				Chemical Constituents of Food				
CLM (Control)	95.00	4.99	4.39	16.32	2.14	4.47	67.68	33.59
	±0.62	±0.06	±0.16	±0.78	±0.53	±0.45	±0.44	±0.88
ADB	95.39	4.61	4.05	25.45	7.26	5.90	52.72	107.18
	±0.28	±0.28	±0.10	±0.11	±0.65	±0.01	±0.27	±0.13
PADB	95.25	4.75	5.39	21.57	10.64	5.50	52.15	89.29
	±0.87	±0.87	±0.25	±0.50	±0.06	±0.44	±0.26	±0.24
APDB	95.35	4.65	4.59	30.39	13.57	6.52	40.29	97.85
	±0.61	±0.61	±0.15	±0.29	±0.12	±0.06	±0.31	±0.19

Source: Field data, Apolala (2020)

-Values are averages of triplicate determinations

-Data is represented as mean ± standard deviation

- The mean difference is significant at the 0.05 level

Table 5 also shows the chemical composition of the formulated complementary food Samples ADB, PADB and APDB and that of the control (cerelac millet complementary food CLM). The results showed that all the formulated complementary foods contained ash, proteins and β- carotene levels as follows (4.05 % - 5.39%, 21.57% - 30.39 & 89.29- 107.18 µg/g respectively). These were higher than the corresponding values reported for the control (CLM) (ash -4.39%, protein -16.32% & β-caroten-33.59 µg/g respectively). CLM (control) rather had higher values for moisture & carbohydrates (4.99% & 67.68% respectively compared to that found in the formulated samples ADB, PADB and APDB) (4.39 µg/g, 16.32 µg/g & 33.59 µg/g respectively).

The carbohydrates content of the formulated complementary food Samples ADB, PADB and APDB ranged from 40.29% - 52.72% whiles that of the CLM (control) had 67.68 % which was above the values for the formulated complementary food Samples. The carbohydrates content of the three formulations were far below the recommended level for infant's food per recommendation by Forsido, *et al.* (2019) to be 65% but the control had a carbohydrate percentage of 67.68% equally above the 65% daily recommendation (Forsido, *et al.,* 2019).

The results further revealed that the ash content of the formulated complementary food samples was higher, and this could be attributed to the high quantities of the pearl millet used in the formulation. The formulated complementary food samples ADB, PADB and APDB were richer in minerals than the control CLM complementary food. The percentage ash found in the complementary food sample was high indicating a high mineral content. The high levels of dawadawa & herring added to the formulated Samples ADB,

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PADB and APDB improve greatly the protein content of the formulated complementary food samples and far exceeded that found in the CLM (Control). These protein levels compared to the recommended levels of protein that ought to be present in the food of infant food 20% (Forsido, Duguma, Lema, Sturm & Hensel, 2019).

However, the formulated samples ADB, PADB and APDB may enhance tissue repair and body building in infants. The variety of tomato used in the formulation has been specially bred for its vitamin A. it is thus not surprising that the formulated complementary food sample had high β-carotene levels. The high levels of β-carotene in the present formulation would help build the immune systems in infants and help fight them diseases common to babies. Past 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 formulated complementary food samples ADB, PADB and APDB had fibre content which far exceeded that of CLM (control). The effect of the fibre on infants may probably be negligible because it is soluble fibre and could help in only enhancing digestion especially in infants (Capuano, 2017). Abeshu et al., (2016) reported that increasing the intake of dietary fibre generally increases stool bulk which causes flatulence and decreases appetite.

Objective three: Determine the Functional properties of the Complementary food being formulated results of the formulated complementary food samples are shown in Table 6.

Table 6: Functional characteristics of the formulated food

Sample	Bulk Density	Dispersibility	Swelling Power	Solubility	Water Aborption Capacity
CLM (Control)	0.69 ±0.00	71.43±0.21	7.40±0.22	32.16± 0.13	168.64±0.30
ADB	0.63±0.00	54.53±0.31	8.15±0.14	28.64±0.35	306.06±0.31
PADB	0.65±0.00	58.53±0.32	11.37±0.48	23.57±0.38	323.68±0.38
APDB	0.62±0.00	47.50±0.20	8.22±0.38	26.23±0.33	346.72±0.33

Source: Field data, Apolala (2020)

*Values are averages of triplicate determinations

**Data is represented as mean ± standard deviation

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

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Bulk Density is an indication of porosity of a product which influences package design. It also assesses the heaviness of flour (Olaitan, N. I., Eke, M. O. & Uja, 2014). Moisture content and particle size of the flour is often affected by the heaviness of the flour (Prasopsunwattana, Omary, Arndt, Cooke, Flores, Yokoyama, Toma & Lee, 2009).

Results from Table 6 show that APDB had the least value for the bulk density amongst the formulated complementary food samples, while the PADB had the highest value for the bulk density. The values recorded in this study were approximately close to what was reported by Laryea (2016), but higher than that reported by Mbaeyi-Nwaoha and Obetta (2016) and lower than that reported by (Olaitan et al., 2014). Okorie et al. (2011) reported that bulk density depends on the particle sizes of the food commodities used, hence the use of smaller particle sized food items is associated with lower bulk density, and vice versa.

Akubor et al. (2013) reported 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 could result in growth faltering (Olaitan *et al.*, 2014). From the results in table 5, all the three (3) formulations ADB, PADB and APDB had lower bulk densities hence are suitable to be used as complementary foods for infant feeding.

Swelling Power was observed to be low amongst the formulated complementary food samples. A higher value was noted in samples PADB (100g pearl millet flour + 20g of herring + dawadawa +onion + tomato powder). ADB (100g pearl millet + 35g of dawadawa powder + 30g of herring+ 20g

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tomato powder + 15g of onion powder) had the least Swelling Power. Results from Table 5 show that the samples could swell up to ten (10) times their original size and weight.

According to Ayo-Omogie and Ogunsakin (2013) and Kinsella (1976) both reported that swelling causes changes in the hydrodynamic proteins of food, which impacts the characteristics of the body of proteins, thickening and increase in viscosity of food. Afam- Anene and Ahiarakwen (2014) asserted that a lower swelling capacity of formulated complementary foods tends to be advantage when it comes to feeding infants because it increases the nutrient density of the food, thereby enabling the child to consume more in order to meet their nutrient requirements. The developed PADB had the highest swelling power and produced a thick viscous porridge after cooking compared to ADB and APDB.

The high swelling power of PADB could probably be due to the high pearl millet flour content. The swelling power values reported in this study were higher than that reported by Ojinnaka et al., (2013) and Laryea (2016). Fasuan et al. (2017) and Ikese et al. (2016) reported high swelling power values than that reported in this study.

Formulated complementary foods with high swelling power are often not desired much because they tend to absorb more water, and this leads to a low nutrient dense food. The swelling power reported in this study indicated that the three (3) formulations ADB, APDB, and PADB had low swelling powers which makes them suitable for use as complementary food.

Table 6 shows that ADB had the highest solubility index followed by APDB and PADB. Solubility is an index of protein functionality such as

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denaturation and its potential application. Therefore, the higher the solubility, the higher the functionality of the protein in the food (Adepeju *et al.,* 2014). Results in Table 5 show that the solubility indices of the formulations ADB, APDB, and PADB were higher when the proportion of herring and dawadawa powder added were high. The solubility indices in the present study were higher than what was reported by Adepeju et al. (2014) and Laryea (2016)

According to Ghasemzadeh & Ghavidel (2011) water absorption capacity is an indication of the amount of water available in food for gelatinisation. Thus, lower absorption capacity of food is desirable for making thinner porridges. The water absorption capacity values differed amongst the three (3) formulations (ADB, APDB and PADB). ADB recorded the least water absorption capacity value while APDB recorded the highest. The water absorption capacity values increased as the quantity of pearl millet flour added to the formulation increased.

The water absorption capacity of the formulated complementary food samples was higher than that which is reported by Laryea (2016), Onoja et al. (2014) and Adepeju et al. (2014). However, Ghasemzadeh and Ghavidel (2011) reported higher values of water absorption when they studied "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 an unfavourable characteristic in complementary feeding because it limits the assimilation of nutrients (Afam-Anene & Ahiarakwem, 2014). Therefore, out of the three (3) formulated complementary foods, ADB had the least water absorption capacity and may provide a better nutrient densed food.

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Objective Four: Sensory Evaluation of the formulated complementary food Acceptability

The sensory characteristics of the formulated complementary food samples are shown in Table 7. Samples were evaluated based on appearance, taste, texture, aroma and overall acceptability using the five-point hedonic scale. The questionnaire used for evaluating products were administered to 56 panel members who attended post-natal session of the West Gonja Hospital during their postnatal visit.

Table 7: Sensory Evaluation of the formulated complementary baby foods

Sample	Appearance	Taste	Texture	Aroma	Overall Acceptability
CLM (Control)	4.78±0.46	4.62±0.59	4.51±0.63	4.51±0.69	4.62±0.65
ADB	4.44±0.86	4.31±0.77	4.24±0.82	4.62±0.59	4.42±0.89
PADB	4.60±0.56	4.42±0.71	4.13±0.64	4.62±0.49	4.55±0.77
APDB	4.58±0.67	4.24±0.88	4.29±0.71	4.62±0.53	4.47±0.74

Source: Field data, Apolala (2020)

*Values are averages of triplicate determinations

**Data is represented as mean ± standard deviation

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

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Table 8: ANOVA results for sensory evaluation of formulated

complementary baby foods

		Sum of Squares	df	Mean Square	F	Sig.
Appearance	Between Groups	3.309	3	1.103	2.548	.057
	Within Groups	93.491	216	.433		
	Total	96.800	219			
Taste	Between Groups	4.559	3	1.520	2.735	.045
	Within Groups	120.036	216	.556		
	Total	124.595	219			
Texture	Between Groups	4.255	3	1.418	2.859	.038
	Within Groups	107.127	216	.496		
	Total	111.382	219			
Aroma	Between Groups	.491	3	.164	.486	.692
	Within Groups	72.691	216	.337		
	Total	73.182	219			
Overall Acceptability	Between Groups	1.250	3	.417	.705	.550
	Within Groups	127.709	216	.591		
	Total	128.959	219			

Source: Field data, Apolala (2020)

The overall acceptability mean score indicated that CLM 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 in Table 7 indicated that CLM (control) was above the other produces, followed by PADB, APDB and ADB. Apart from CLM having a

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higher mean score of 4.78± 0.46, PADB score was almost closer to it than the other two samples in terms of appearance. The difference between CLM and PADB in terms of their mean score for appearance was 0.16 which shows that there was no significant difference at (p< 0.05) for appearance of the samples.

The taste of CLM (control) was rated highest compared to the rest of the formulated complementary food samples ADB, PADB, and APDB. However, APDB was judged the least tasteful product. The results for the taste analysis of the samples as shown in Table 7 showed that the differences between the mean scores for CLM and PADB was 0.16. This indicates that there was barely any significant difference in the taste of CLM and PADB at (p< 0.05) in the taste of these products.

The mean score for texture was high for CLM followed by APDB with PADB having the lowest mean score for texture. The difference in the value for texture between CLM and APDB was 0.22 shows no significant difference at (p< 0.05) between the texture of CLM and APDB.

Panel members rated aroma of products in the following ranges of 4.62 and 4.51. ADB was rated as highest followed by APDB and APBD while CLM had the least aroma rating. The value difference between ADB, PADB, APDB and CLM was 0.11. There was very little difference in the aroma of the three samples, specifically no that there were no significant differences (p< 0.05) in the aroma of the samples.

Appearance scores assigned to the complementary food samples increased as product had less dawadawa. The different ratios used in formulating the food samples contributed much to the different appearance and colour of the samples. The panellist reported that they preferred colourful foods

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because they know that babies are easily attracted to bright colours, so it was not surprising that the panellists reported that. Spence (2015) reported that colour and appearance are the initial quality features that attract people to food product and this is in line with what the panellists stated. Colour and appearance inherent characteristics for good quality of foods and is equally associated with the acceptability (Singh- Ackbarali & Maharaj 2014). Colour of CLM was the most preferred among the products.

CLM was rated the highest in terms of taste, however, there was a marginal value difference between CLM and PADB. The high taste score for PADB may be attributed to the higher quantity of dawadawa and herring used, and smaller amount of pearl millet powder used in the formulation. Herrings and dawadawa have peculiar strong smell and unique taste. According to Bazaz, Baba and Masoodi. (2016), they have reported that taste is an important attribute in sensory evaluation of food. A product may be appealing to the eye and have a high energy density but may not taste and smell well, such a product is likely to be rejected by consumers.

PADB product and CLM were evaluated and accepted on the same level. The higher pearl millet flour added in the formulation gave it a sweeter taste and reduced the strong and pungent smell and taste of the dawadawa and Herring powder. Even though CLM had the best rating for taste. Four of the panel members liked the taste of all the formulated complementary food samples except the control CLM. Ten of the panel member liked CLM a lot while another 15 scored CLM (control) high for taste.

APDB scored highest for texture and this may be attributed to addition of increased amounts of pearl millet flour to the sample compared to the other

samples. Even though APDB had the highest score for texture, some of the panellists complained about the coarse nature of the formulated samples. This coarseness may be attributed to the particle size of the flour. Panel members suggested that the flour should be made finer to improve its consumption by the panel members.

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

In terms of aroma all the three samples ADB, PADB and APDB had the same mean scores. This may have produced a mild aroma which may have influenced the panel members to like it. CLM (control) was found to have aroma which may be attributed to the different ingredients used for the control (CLM). According to Bazaz et al (2016), aroma is an integral part of taste and helps in accepting food prior to it being put in the mouth. It is therefore an important parameter to consider when evaluating the acceptability of food samples. Although CLM (control) had the least score for aroma, most of the panel members liked it but four others rated the aroma of CLM to be poor.

The results as shown in Table 7 indicate that the overall acceptability score for CLM was highest, followed by PADB and then APDB, with ADB having the least overall acceptability score. CLM (control) was accepted based on the attributes presented (taste, aroma, texture and appearance). The panel members chose CLM to be the best among the o samples. Probably the appearance of CLM (control) was more attractive babies by nature are attracted

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to bright colours and the same argument can be made for CLM (control). Looking at the mean score for the four samples shown in Table 7, CLM (control) 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 panel members were provided with water to rinse their mouth after tasting each sample. This removed all traces of the previous foods tasted to prevent any form of bias. The mean value for the taste of CLM (control), was the highest.

Hypotheses

Ho₁: There is no statistically significant difference between the sensory properties of the developed complementary ADB (Apolala Diet Blend) and commercially manufactured Cerelac millet.

Table 9: Result of Independent sample t-test of ADB and Commercially manufactured food (CLM) Acceptability

	Formulations	N	Mean	Std. Dev.	df	t-value	Sig. (2-tailed)
Overall	CLM	55	4.62	.652	108	1.338	1.338
Accepta-	ADB	55	4.42	.896			
bility							

Source: Field data, Apolala (2020)

Table 9 presents the results for the independent sample t-test for ADB and CLM in terms of acceptability by the panel members. The mean score for CLM was a little higher than that of ADB with a margin of 0.2, t-value of 1.338 which gave significance (2-tailed) of 1.338. The significant value being higher

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than the a-value of 0.05 suggest that the null hypothesis was accepted on the basis that the p-value obtained was more than a-value of 0.05. This implies that there is no statistically significant difference between the developed complementary food ADB and the commercially manufactured CLM.

Ho2: There no statistically significant difference between the sensory properties of the developed complementary food PADB (Pearl Apolala Diet Blend) and the commercially manufactured Cerelac millet.

Table 10: Result of the independent Sample t-test of PADB and CLM Acceptability

	Formulations	N	Mean	Std. Dev.	df	t-value	Sig. (2-tailed)
Overall	CLM	55	4.62	.652	.536	108	0.593
Acceptability	PADB	55	4.55	.765			

Source: Field data, Apolala (2020)

Table 10 presents the independent sample t-test results on the acceptability of CLM (control) and PADB. CLM mean score was slightly higher than that of PADB a margin of 0.07. A t-value of 108 showed statistically significance (2-tailed) of 0.593 which was higher than the a-value of 0.05. In view of the statistically significant value (2 tailed) being lower, the null hypothesis was accepted on the basis that the p-value of 0.593 was equivalent to the a-value of 0.05. This implies that there was no statistically significant difference between the developed complementary food PADB and the commercially manufactured CLM (control).

Ho₃: There no statistically significant difference between the sensory properties of the developed Complementary food APDB (Apolala Pearl Diet Blend) and the commercially manufactured Cerelac millet.

Table 11: Acceptability of Infant formula APDB and CLM

	Formulations	N	Mean	Std. Dev.	df	t	Sig. (2-tailed)
Overall Acceptability	CLM	55	4.62	.652	1.092	108	0.277
	APDB	55	4.47	.742			

Source: Field data, Apolala (2020)

Table 12: ANOVA result of food acceptability

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.448	2	.224	.347	.707
Within Groups	104.727	162	.646		
Total	105.176	164			

Source: Field data, Apolala (2020)

Table 11 shows the independent sample t-test of the acceptability of APDB and CLM by panel members. The mean score for CLM was a little higher than that of APDB with a margin of 0.15, t-value of 108 given significance (2 tailed) of 0.277 which is higher than the a-value of (0.05). In view of the fact that statistically significant (2 tailed) being higher the null hypothesis was accepted on the basis that the p-value of 0.277 was more than a-value of 0.05.

This implies that there was no statistically significant difference between the developed complementary food APDB and the commercial manufactured (CLM).

Ho4: There no statistically significant difference among the three-product developed in terms of their nutritional content.

Table 13: Means and standard deviation of ANOVA Statistics

Sample	N	Mean	Std. Deviation	Std. Error
ADB	55	4.42	.896	.121
PADB	55	4.55	.765	.103
APDB	55	4.47	.742	.100
Total	165	4.48	.801	.062

Source: Field data, Apolala (2020)

Table 13 shows the ANOVA of ADB, PADB and APDB in terms of nutritional difference among the three (3) complementary food developed. The results in table 11 implies there was no significant difference in terms of nutrient among the three (3) complementary food samples developed. The margin between ADB &PADB was 0.13, ADB &APDB was 0.5, PADB & APDB was 0.8 and PADB & ADB was 0.13. The mean value for the three (3) complementary food developed was 4.48. The above analysis on the three complementary food samples developed shows that there were no statistically significant differences among the three complementary food samples developed.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Overview of the Study

The summary, conclusions and recommendations of the study has been presented in this chapter. Suggestions for further studies has also been presented. The purpose of the study was to develop or formulate complementary food from pearl millet, dawadawa, herring, tomato and onion.

The developed complementary food could help address malnutrition and anemia 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 statistically significant differences that existed between the formulated complementary food (ADB, APDB &PADB) and CLM (control). IBM-SPSS version 25 for Windows was used to analyze data. Frequency, percentage, means, standard deviation, independent t-test were the tools used in the data analysis.

Key Findings

1. As stated in objective one the three infant formula was successfully developed without problems from the local food items (pearl millet, dawadawa, herring, tomato and onion) and was coded with ADB, PADB and APDB to hide the true identity of the formulation.

2. Proximate analysis was done to identify the chemical constituents of the developed complementary food (ADB, PADB and APDB) and the control (CLM). From the result apart from carbohydrate that CLM (control) had the highest, the rest like (moisture, ash, protein, β-carotene,

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fibre fat & Oil) was high in the formulated complementary food (ADB, PADB and APDB).

3.   The functional characteristics that was done on the developed complementary infant formula (ADB, PADB and APDB) as well as the control (CLM). The results revealed that CLM had high values for bulk density, dispersibility and solubility, whilst the developed complementary food (ADB, PADB and APDB) had high values for swelling power and water absorption capacity and this could be due to the different ingredient used.

4.   A sensory evaluation was done for the formulated complementary infant food (ADB. PADB and APDB) and the control (CLM). The result showed that CLM (control) had the high values for appearance, taste and texture (4.78, 4.62 & 4.51) respectively and the formulated infant complementary food (ADB, PADB &APDB) recorded high value for aroma with a value of 4.62. The overall acceptability was recorded by CLM, this was because CLM was known by the panelists and mothers has being feeding them with CLM and it even made with sugar.

5.   Analysis was also done for the four hypotheses and the result revealed that there were no statistically significant differences between the sensory properties of the developed complementary infant food and commercially manufactured Cerelac millet. Hypothesis one (1) the difference was 0.2 between ADB and CLM; hypothesis two (2) the difference was 0.07 between PADB and CLM; hypothesis three (3) the difference was 0.15 between APDB and CLM and hypothesis four (4) the difference was 4.88 between the three formulated complementary

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food and CLM. Hence since there was no much difference, it implies

that there was no statistically significant difference from the developed

complementary food and the commercial manufactured Cerelac millet.

6.   The colour of the formulated complementary food looked dark and this

was due to the ratio of dawadawa added to the formula.

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 CLM (Control) which is expensive. The ingredients to produce

the new formula (ADB, PADB and APDB) were locally acquired and can be

affordable. The new formulations (ADB, PADB and APDB) would help fight

the persistent malnutrition and anaemia deficiencies among infants in West

Gonja, Northern region and Ghana. The results showed that the raw materials

used (Pearl millet, dawadawa, herring, tomatoes and onion) are very rich in

protein, carbohydrates and rich in B- carotene. Mothers could take advantage

of the new formulations when finally produced in commercially quantities to

supplement the local foods for infants.

The method employed in this study can be adopted by NGOs,

household, companies and community levels to produce nutrient dense

complementary foods to help reduce the menace of malnutrition and anaemia

deficiencies among infants in Ghana and especially Northern region where

malnutrition and anaemia is high.

Recommendations

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

1. There is the need to employ different drying methods in drying the food commodities used in the formulation.

2. A further study should still be done on the formulated infant foods but the percentage of the dawadawa should be reduce to give the formula a good colour.

3. There is the need to conduct studies on microbial count for the most preferred formulated complementary food.

4. The shelf life of the most preferred formulated complementary food could be studied.

5. A clinical studies should be done where the formulated products should be fed to children under five who are malnourished or anaemic for a period to see the effectiveness of the product.

6. Industry could also take this study as a prototype and produce in large quantity after the shelf life of the product have been study.

7. Policymakers could also adopt the study to help achieve the sustainable development goal two which aims to end all forms of hunger and malnutrition by 2030.

8. Anthropometric studies to determine how babies will fare on the product.

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APPENDICES

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APPENDIX A

SENSORY EVALUATION QUESTIONNAIRE

Sensory Evaluation of pearl millet complementary infant formula

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-Like very much

Please give the child water before and after ta

Coded Sample	Appearance	Taste	Texture	Aroma	Overall Acceptability
CLM					
ADB					
PADB					
APDB					

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APPENDIX B

LAKAL BE KECHƆNKENI BE MBISHI

Lakal be ketachɔ mbia pɔpɔrbi nkeni ta nlaŋɛ adurbi be ajibi be kapilia so.

Kachɛ………………………………..

Jande migeto, sa mbia adurbi be ajibi ere gbrɛbi nɛ bu da nkenini nɛ fo sulwe

bumo so ta nlaŋɛ kamanɛ bu saŋɛ anishito nko nkre anishito. Ŋini to kananɛ

mbia bee sha ajibi ere nko kananɛbu kishi amo ta nlaŋɛ amobe anishiso, kɔnɔto,

kapɔrto,afɛ nɛ kananɛ bu shuliso nsa amobe keji kikɛ. Ta amofoniana ere n ŋini

kananɛ bu shuliso nsa amo n shin ta alamba dagaso mmata kekama so.

Coded Sample	kananɛ adu kinishiso	kananɛ adu konɔto	Amobe kporto	Amobe afɛ	kananɛ bu shuliso nsa amo kikɛ
CLM					
ADB					
PADB					
APDB					

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APPENDIX C

KEBUWITO BE KESHULINSA BE KAWOL

KESHULINSA BE KAWOL

Keshulinsa nchɛto nchɔ mbia pɔpɔrbi nkeni ta nlaŋɛ adurbi be ajibi be kapilia.

Mee wɔrɔ kemɛgto nna ta nlaŋɛ mbia be lakal nɛ ajibichɛto monɛ anye ta adurbi, achɔn, ameni, kelibashi nɛ tamatosi n loŋɛ. Loŋ be ajibi ere bee chɛto nɛ anyebe mbia bee kpeŋto nshin naa chɛto nɛ Ghana nɛ Wenst Gonja be mbianyiposo be nklaŋ bee nite nɛnɛ.

Mbishi ere be atuwebi beeŋ ji fobe jenanɛ beeŋ wɔrɔ fanɛ aminti 20. Ajibichɛtopo ere be amɛtoso anɔ kasato ere na. Adurbi ameni, achon, kelibashi nɛ tamasi.

Fobe Kabia be kpaga kaa kishi amatosɔ ere be kakama fo yige kemɛgto ere be ketuwe.

Ne fo kaŋ shuliso nsa kemɛgeto ere fo ti yishi enɔ n sa keshuliso be kawo; na. Fobe anishi ashi kemɛgeto ere to boshini nna. Fo ku wɔrɔ kemɛgeto ere la aparsheŋ nna. Feeŋ tiŋ n yige nko n kin jemanɛ kama nɛ fee sha. Nɛ fo kaa kɔ mbishi kikɛ feeŋ tiŋ bishi, Fobe tangrafol:

APOLALA BATIDOW MARTINA

0200120259/0241274908

N kraŋ /Esa ko kraŋ nshin puŋpuŋto nɛnɛ kemɛgeto ere n sa ma nɛ n shuliso fanɛ meeŋ chɛto nɛ kemɛgeto ere.

……………………..   …………………………

Echɛtopo be keyishi enɔ

    Kachɛ

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APPENDIX D

ETHICAL CLEARANCE

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 4358931413 / 0508070509 4244367814   C/O Directorate of Research, Innovation and Consultancy
E-MAIL: irb@ucc.edu.gh
OUR REF: UCCIRB/A/2016/990
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096   11TH FEBRUARY, 2020

Ms. Martina Apolala Ihatidow
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms. Hatidow,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2019/57)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research protocol titled **Pearl Millet Use in Complementary Infant Formula**. This approval is valid from 11th February, 2020 to 10th February, 2021. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

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

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,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST

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APPENDIX E

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 of Cape Coast
Cape Coast

Our Ref: VTE/IALⁿ/V.2/256

14th August, 2019

The Director
West Gonja Hospital, Damongo
Savanna Region

Dear Sir,

INTRODUCTORY LETTER ETHICAL CLEARANCE

We have the pleasure of introducing to you **Ms. Apoluia Batidow Martina** who is an M.Phil student of this Department and working on the thesis topic **"Pearl Millet Use in Complementary Infant Formula".**

She is currently on data collection stage and requires your permission to gather data from your institution to complete the thesis.

We would be grateful if you could give her the necessary assistance.

Thank you.

Yours faithfully

Prof. Sarah Darkwa
HEAD OF DEPARTMENT

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APPENDIX F

CHEMICAL CONSTITUENT OF FORMULATION

						95% Confidence Interval for Mean	
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
%DM	ADB	3	88.61957	.101233	.058447	88.36809	88.87104
	PADB	3	88.61303	.200118	.115538	88.11591	89.11015
	APDB	3	88.91980	.027510	.015883	88.85146	88.98814
	Total	9	88.71747	.189207	.063069	88.57203	88.86290
%Moisture	ADB	3	11.38043	.101233	.058447	11.12896	11.63191
	PADB	3	11.38697	.200118	.115538	10.88985	11.88409
	APDB	3	11.08020	.027510	.015883	11.01186	11.14854
	Total	9	11.28253	.189207	.063069	11.13710	11.42797
%Ash	ADB	3	3.67713	.161232	.093087	3.27661	4.07766
	PADB	3	3.35247	.130213	.075178	3.02900	3.67593

Descriptives

	APDB	3	4.25807	.134727	.077785	3.92339	4.59275
	Total	9	3.76256	.416114	.138705	3.44270	4.08241
%Protein	ADB	3	27.05243	.094956	.054823	26.81655	27.28832
	PADB	3	22.48067	.464548	.268207	21.32667	23.63467
	APDB	3	27.19893	.060436	.034893	27.04880	27.34906
	Total	9	25.57734	2.335634	.778545	23.78202	27.37267
%Fat and Oil	ADB	3	10.09623	.004771	.002755	10.08438	10.10809
	PADB	3	8.54840	.097727	.056423	8.30563	8.79117
	APDB	3	14.08053	.051318	.029628	13.95305	14.20801
	Total	9	10.90839	2.472331	.824110	9.00799	12.80879
%Fibre	ADB	3	5.42380	.058912	.034013	5.27746	5.57014
	PADB	3	5.92630	.038970	.022499	5.82949	6.02311
	APDB	3	5.58440	.041661	.024053	5.48091	5.68789
	Total	9	5.64483	.226010	.075337	5.47111	5.81856
%CHO	ADB	3	42.37003	.204149	.117866	41.86290	42.87717

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	PADB	3	48.30517	.419932	.242448	47.26200	49.34834
	APDB	3	37.79780	.092605	.053466	37.56776	38.02784
	Total	9	42.82433	4.568767	1.522922	39.31247	46.33620
B Carotene	ADB	3	112.39020	.328483	.189650	111.57420	113.20620
	PADB	3	108.79113	.285225	.164674	108.08260	109.49967
	APDB	3	106.76850	.378778	.218688	105.82756	107.70944
	Total	9	109.31661	2.482773	.827591	107.40818	111.22504

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Descriptives		Minimum	Maximum
%DM	ADB	88.530	88.729
	PADB	88.465	88.841
	APDB	88.901	88.951
	Total	88.465	88.951
%Moisture	ADB	11.271	11.470
	PADB	11.159	11.535
	APDB	11.049	11.100
	Total	11.049	11.535
%Ash	ADB	3.491	3.774
	PADB	3.202	3.432
	APDB	4.172	4.413
	Total	3.202	4.413
%Protein	ADB	26.943	27.112
	PADB	22.094	22.996
	APDB	27.130	27.243
	Total	22.094	27.243
%Fat and Oil	ADB	10.092	10.102
	PADB	8.474	8.659
	APDB	14.022	14.115
	Total	8.474	14.115

%Fibre	ADB	5.370	5.487
	PADB	5.897	5.970
	APDB	5.560	5.633
	Total	5.370	5.970
%CHO	ADB	42.136	42.509
	PADB	47.823	48.592
	APDB	37.699	37.882
	Total	37.699	48.592
B Carotene	ADB	112.106	112.750
	PADB	108.568	109.112
	APDB	106.357	107.103
	Total	106.357	112.750

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
%DM	Between Groups	.184	2	.092	5.415	.045
	Within Groups	.102	6	.017		
	Total	.286	8			
%Moisture	Between Groups	.184	2	.092	5.415	.045
	Within Groups	.102	6	.017		
	Total	.286	8			
%Ash	Between Groups	1.263	2	.632	31.005	.001

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	Within Groups	.122	6	.020		
	Total	1.385	8			
%Protein	Between Groups	43.185	2	21.592	283.520	.000
	Within Groups	.457	6	.076		
	Total	43.642	8			
%Fat and Oil	Between Groups	48.875	2	24.437	6005.818	.000
	Within Groups	.024	6	.004		
	Total	48.899	8			
%Fibre	Between Groups	.395	2	.198	88.149	.000
	Within Groups	.013	6	.002		
	Total	.409	8			
%CHO	Between Groups	166.536	2	83.268	1102.420	.000
	Within Groups	.453	6	.076		
	Total	166.989	8			
B Carotene	Between Groups	48.648	2	24.324	219.314	.000
	Within Groups	.665	6	.111		
	Total	49.313	8			

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Post Hoc Tests

Homogeneous Subsets

%DM		
Tukey B[a]		
		Subset for alpha = 0.05
Sample	N	1
PADB	3	88.61303
ADB	3	88.61957
APDB	3	88.91980

Means for groups in homogeneous

subsets are displayed.

a. Uses Harmonic Mean Sample

Size = 3.000.

%Moisture

Tukey B[a]

		Subset for alpha = 0.05
Sample	N	1
APDB	3	11.08020
ADB	3	11.38043
PADB	3	11.38697

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Means for groups in homogeneous

subsets are displayed.

a. Uses Harmonic Mean Sample

Size = 3.000.

%Ash

Tukey B[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
PADB	3	3.35247		
ADB	3		3.67713	
APDB	3			4.25807

Means for groups in homogeneous subsets are

displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

%Protein

Tukey B[a]

Sample	N	Subset for alpha = 0.05	
		1	2
PADB	3	22.48067	
ADB	3		27.05243
APDB	3		27.19893

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Means for groups in homogeneous subsets

are displayed.

a. Uses Harmonic Mean Sample Size =

3.000.

%Fat and Oil

Tukey B[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
PADB	3	8.54840		
ADB	3		10.09623	
APDB	3			14.08053

Means for groups in homogeneous subsets are

displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

%Fibre

Tukey B[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
ADB	3	5.42380		
APDB	3		5.58440	
PADB	3			5.92630

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Means for groups in homogeneous subsets are

displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

%CHO

Tukey B[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
APDB	3	37.79780		
ADB	3		42.37003	
PADB	3			48.30517

Means for groups in homogeneous subsets are

displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

B Carotene

Tukey B[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
APDB	3	106.76850		
PADB	3		108.79113	
ADB	3			112.39020

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

APPENDIX G

SENSORY ACCEPTABILITY OF FOODS

						95% Confidence Interval for Mean
		N	Mean	Std. Deviation	Std. Error	Lower Bound
Appearance	CLM	55	4.78	.459	.062	4.66
	ADB	55	4.44	.856	.115	4.21
	PADB	55	4.60	.564	.076	4.45
	APDB	55	4.58	.686	.092	4.40
	Total	220	4.60	.665	.045	4.51
Taste	CLM	55	4.62	.593	.080	4.46
	ADB	55	4.31	.767	.103	4.10
	PADB	55	4.42	.712	.096	4.23
	APDB	55	4.24	.881	.119	4.00
	Total	220	4.40	.754	.051	4.30
Texture	CLM	55	4.51	.635	.086	4.34
	ADB	55	4.24	.816	.110	4.02
	PADB	55	4.13	.640	.086	3.95
	APDB	55	4.29	.712	.096	4.10
	Total	220	4.29	.713	.048	4.20
Aroma	CLM	55	4.51	.690	.093	4.32

Table caption: Descriptives

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	ADB	55	4.62	.593	.080	4.46
	PADB	55	4.62	.490	.066	4.49
	APDB	55	4.62	.527	.071	4.48
	Total	220	4.59	.578	.039	4.51
Overall Acceptability	CLM	55	4.62	.652	.088	4.44
	ADB	55	4.42	.896	.121	4.18
	PADB	55	4.55	.765	.103	4.34
	APDB	55	4.47	.742	.100	4.27
	Total	220	4.51	.767	.052	4.41

Descriptives				
		95% Confidence Interval for Mean		
		Upper Bound	Minimum	Maximum
Appearance	CLM	4.91	3	5
	ADB	4.67	1	5
	PADB	4.75	3	5
	APDB	4.77	3	5
	Total	4.69	1	5
Taste	CLM	4.78	2	5
	ADB	4.52	2	5
	PADB	4.61	2	5
	APDB	4.47	2	5
	Total	4.50	2	5

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Texture	CLM	4.68	3	5
	ADB	4.46	2	5
	PADB	4.30	2	5
	APDB	4.48	2	5
	Total	4.39	2	5
Aroma	CLM	4.70	2	5
	ADB	4.78	3	5
	PADB	4.75	4	5
	APDB	4.76	3	5
	Total	4.67	2	5
Overall Acceptability	CLM	4.79	2	5
	ADB	4.66	1	5
	PADB	4.75	2	5
	APDB	4.67	2	5
	Total	4.62	1	5

ANOVA					
		Sum of Squares	df	Mean Square	F
Appearance	Between Groups	3.309	3	1.103	2.548
	Within Groups	93.491	216	.433	
	Total	96.800	219		

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Taste	Between Groups	4.559	3	1.520	2.735
	Within Groups	120.036	216	.556	
	Total	124.595	219		
Texture	Between Groups	4.255	3	1.418	2.859
	Within Groups	107.127	216	.496	
	Total	111.382	219		
Aroma	Between Groups	.491	3	.164	.486
	Within Groups	72.691	216	.337	
	Total	73.182	219		
Overall Acceptability	Between Groups	1.250	3	.417	.705
	Within Groups	127.709	216	.591	
	Total	128.959	219		

ANOVA		
		Sig.
Appearance	Between Groups	.057
	Within Groups	
	Total	
Taste	Between Groups	.045
	Within Groups	

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	Total	
Texture	Between Groups	.038
	Within Groups	
	Total	
Aroma	Between Groups	.692
	Within Groups	
	Total	
Overall Acceptability	Between Groups	.550
	Within Groups	
	Total	

Post Hoc Tests

Homogeneous Subsets

Appearance

Tukey B[a]

		Subset for alpha = 0.05	
Formulations	N	1	2
ADB	55	4.44	
APDB	55	4.58	4.58
PADB	55	4.60	4.60
CLM	55		4.78

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Means for groups in homogeneous subsets are

displayed.

a. Uses Harmonic Mean Sample Size = 55.000.

Taste			
Tukey B[a]			
		Subset for alpha = 0.05	
Formulations	N	1	2
APDB	55	4.24	
ADB	55	4.31	4.31
PADB	55	4.42	4.42
CLM	55		4.62

Means for groups in homogeneous subsets

are displayed.

a. Uses Harmonic Mean Sample Size =

55.000.

Texture			
Tukey B[a]			
		Subset for alpha = 0.05	
Formulations	N	1	2
PADB	55	4.13	
ADB	55	4.24	4.24
APDB	55	4.29	4.29
CLM	55		4.51

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Means for groups in homogeneous subsets are

displayed.

a. Uses Harmonic Mean Sample Size = 55.000.

Aroma

Tukey B[a]

Formulations	N	Subset for alpha = 0.05
		1
CLM	55	4.51
ADB	55	4.62
PADB	55	4.62
APDB	55	4.62

Means for groups in homogeneous

subsets are displayed.

a. Uses Harmonic Mean Sample Size =

55.000.

Overall Acceptability

Tukey B[a]

Formulations	N	Subset for alpha = 0.05
		1
ADB	55	4.42
APDB	55	4.47
PADB	55	4.55
CLM	55	4.62

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Means for groups in homogeneous

subsets are displayed.

a. Uses Harmonic Mean Sample Size =
55.000.