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Preparation of some Weaning Food formulated from Sweet Potato, Millet and Quinoa

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ABSTRACT

The aim of this study is to a formulate a weaning food from**:** Orange-fleshed sweet potato flour, germinated Pearl millet and pre-cooked quinoa (PMQ formula) which is used for infants Aged 6 to 24 months. The Weaning food product (PMQ) was manufactured by orange-fleshed sweet potato flour, germinated Pearl millet and drying a pre-cooked quinoa (*Chenopodium quinoa,* Willd) flour which were blended together at the following six different ratios**:** 0:100:0(1), 10:60:30(2), 10:50:40(3), 10:40:50(4), 10:30:60(5) and 10:20:70(6), respectively. These six flour blends were used to prepare weaning foods. Chemical Analysis and Sensory attributes of foods were determined using a nine-point Hedonic Scale. The flour blend with the highest overall acceptability score (10:30:60 PMQ) was compared with commercial weaning food. During eight weeks of storage, the functional and chemical properties of the flour blend were determined every two weeks. Results obtained from the sensory properties of the weaning food shows that the sample 10:30:60(5) was accepted by the panelists. The levels of protein (14.19 g/100 g), fat (4.58 g/100 g), carbohydrate (76.7 g/100 g), and energy (404.78 kcal/100 g) of the PMQ weaning food met both the specifications of the Codex Standard (1991) and the Egyptian Standard No. 3284 (2005). The essential Amino Acid contents of the PMQ weaning food were higher than the amino acid profile of the Food and Agriculture Organization/World Health Organization/United Nations University .The PMQ weaning food had high levels i.e. (50.56%) of Polyunsaturated Fatty Acids. However, the highest level of saturated fatty acids i.e. (51%) was recorded for the commercial weaning food. The sensory evaluation results, show that the PMQ weaning food was acceptable in Aroma (7.2), Taste (7.3), color (7. 6), Viscosity (6.9) where the Overall Acceptability is (7.27). The functional properties of the blend during storage for 8 ranged from 0.55 to 0.61 g/mL, 92.77to73.30 %, 4.32 to 3.79 g/g, 3.56 to2.9 %, and 85.00 to 67.00 % for bulk density, water absorption capacity, Swelling power(g/g), Solubility index and dispersaibility respectively whereas the chemical analysis of PMQ(10:30:60) during storage for 8 weaks ranged from 7.35 to 9.22%, 1.12 to 3.19% and 0.07 to 1.23 meq/kg for moisture, free fatty acids, and peroxide value, respectively.

Keywords: weaning food, Orange-fleshed sweet potato**,** Pearl millet, quinoa

Introduction

Weaning period of an infant is the period when exclusive breast feeding is stopped and baby is gradually introduced to solid foods. At six months, baby's weight is expected to have doubled requiring extra nutrient from other food source other than breast milk to meet their nutritional need. Feeding of young infants must closely match nutrient needs, since growth is the most sensitive and readily measured indicator of health and nutrition for individual child. The most commonly used weaning food in Africa is a thin cereal gruel that is called by different names depending on the type of cereal or country(Agugo *et al.,* 2013). The semisolid foods given to the child at this stage are generally called weaning foods. Weaning foods are adult foods, modified by processing the ingredients to make them easily digestible by the infant (Sajilata *et al.,* 2002).

Accessibility to affordable, healthy food is essential for good health as poor nutrition is one of the major determinants of impaired growth and development, acquisition of certain diseases and later chronic diseases (Allen, 2003). In developing countries, baby food are mainly based on starchy tubers like cassava, cocoyam, and sweet potato, or on cereals like maize, rice, wheat, sorghum, and millet. Small children are normally given these staples in the form of gruels that are mixed with boiled water or boiled with water. When prepared in this way, the starch structures bind large amounts of water, which results in gruels of high viscosity (Hellstrom *et al*., 1981).

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Cereals, individually or as composites, are the main source of nutrients for weaning children in developing countries (Malleshi *et al*.,1989; King *et al*., 1985).From cereals quinoa watch has high protein content. Protein nutritional quality is determined by the proportions of essential amino acids, which are present in quinoa and is close to the ideal protein balance recommended by FAO and similar to milk protein (Comai *et al*., 2007; Gross *et al*., 1989; Spehar and Souza, 1993). Quinoa seed lipids appear to be a high quality edible vegetable oil, similar in fatty acid composition to soybean oil (Valencia-Chamorro *et al*., 2004). Starch is the most important carbohydrates in all quinoa grains, making up approximately 58.1-64.2% of the dry matter (Repo-Carrasco *et al*., 2003). In quinoa, the starch has excellent freeze-thaw stability, what makes it an ideal thickener in frozenfoods and other applications where resistance to retrogradation is desired (Ahamed *et al*., 1998). Moreover, quinoa is gluten-free and the point of view of vegetarian consumers, quinoa in combination with other cereals might easily replace meat. Because of its high nutritional quality and multiple uses in food products make quinoa an ideal for utilization by the food industry, being considered an alternative food (Vega-Gálvez *et al*., 2010).

It is stated that quinoa may benefit high-risk group consumers, such as children, the elderly, high-performance sports people, individuals with lactose intolerance, women prone to osteoporosis, people with anemia, diabetes, dyslipidemia, obesity, and celiac disease due to its properties including a high nutritional value, therapeutic features, and gluten-free content. These features are considered to be linked with the existence of the fiber, minerals, vitamins, fat acids, antioxidants, and especially phytochemicals in quinoa, and they provide quinoa a big advantage over other crops in terms of human nutrition and health maintenance (Repo-Carrasco-Valencia *et al*., 2010; Pasko *et al*., 2010 and Bhargava *et al*., 2006).

Among cereals, pearl millet (*Pennisetum glaucum, syn. P. americanum, P. typhoideum*) ,originated in Central tropical Africa and is widely distributed in the drier tropics and India. It was introduced into the Western state in the 1850's and became established as minor forage in the South east and Gulf Coast states. The plant was probably domesticated as a food crop some 4000 to 5000 years ago along the Southern margins of the Central highlands of the Sahara. It has since become widely distributed across the semiarid tropics of Africa and Asia (Dayakar *et al*., 2017). Nutritionally pearl millet is superior to major cereals in terms of high quality protein, fat, dietary fiber and minerals (calcium, iron, zinc)(Malik *et al*., 2002). Antioxidant components and antioxidant activities of pearl millet was reported by Suma and Asna, (2014). Pearl millet was subjected to various processing methods such as milling, boiling, pressure cooking, roasting and germination respectively. The bran rich fraction showed high antioxidant activity due to presence of high tannin, phytic acid and flavonoid levels. Heat treatments such as boiling, pressure cooking and roasting exhibited significantly ($P \leq 0.05$) higher antioxidant activity reflecting the high flavonoid content. Pearl millet is considered to have one of the best protein quality or amino acid scores. The nutritional value of pearl millet is greatly enhanced when mixed with legumes because the latter complement its profile of essential amino acids (Serna-Saldivar *et al*., 1991). Malting induces important beneficial biochemical changes in the millet grain. Moreover, soaking generates grain softening and increases water absorption. Enzymes produced during germination are responsible for hydrolysis of starch and proteins, which makes sugar and peptides/amino acids directly available. Furthermore, proteolytic enzymes improve the availability of limiting amino acids such as lysine, methionine, and tryptophan (Akoma *et al*., 2006; Badau *et al*., 2005; Mahgoub and Elhag, 1998).

Pearl millet semi refined flour was low in antinutrients which improved mineral bioaccessibility. Because of high dietary fiber, mineral and fat, bran rich fraction could be used as a functional ingredient in formulation of value added products. Germinated pearl millet flour was lighter and finer with high bulk density, which is a desirable attribute in infant/ health food formulations. Household processing methods such as soaking, boiling and germination lowered phytate phosphorus and increased calcium, magnesium, iron and zinc content. Considering the various processing methods reported in this review, it was apparent that simple household techniques may be employed to improve the nutritional quality of pearl millet by making the nutrients more digestible and bioavailable as well as enhancing the flavor and taste of the product(Suma and Asna,2017).

Orange flesh sweet potato has been reported to increase vitamin A intake and serum retinol concentrations in children (Bonsi *et al*., 2014), as well as other micronutrients such as polyphenols and carotenoids (Haskell *et al*., 2004).Two studies conducted in sub-Saharan Africa demonstrated that

consumption of boiled orange fleshed sweet potato improves vitamin A status of children and can significantly complement vitamin A supplementation initiatives to minimize vitamin A deficiency (Low *et al*., 2007) β-Carotene from sweet potato is substantially better in terms of bioavailability than that from leafy vegetables or other vegetables (Allen and Gillespie, 2001). Sweet potato may be processed into flour to avoid the problems associated with perishability of the raw roots (Van Hal, 2000). sweet potato makes these foods a healthy complement to young children's diets. Infant food of more than 20% concentration (w/v) is too thick for an infant's gastric system while if lower than 20% (w/v), might be low in energy and nutrient densities (Walker *et al*. ,2002).

The aim of this study was to a formulate a weaning food from orange-fleshed sweet potato flour, germinated Pearl millet and pre-cooked quinoa (PMQ formula) for infants aged 6 to 24 months which were suitably processed into flours using home processing and have good properties storsge .The nutritional and sensory characteristics of the formulated weaning food were compared with those of the commercial weaning food produced by Cerelac.

Materials and Methods

Pearl millet (*Pennisetum glaucum*), quinoa **(***Chenopodium Quinoa* Willd**)** were obtained from crop research institute, agriculture research center Giza Egypt, and orange-fleshed sweet potato were purchased from the local market in Giza, Egypt. The commercial weaning food (Cerelac) was purchased from a pharmacy in Giza. All reagents and chemicals were of analytical grade.

Preparation of orange-fleshed sweet potato flour

Sweet potato roots were washed, peeled with a stainless steel knife, and immersed in 0.5% sodium acid pyrophosphate solution to prevent discoloration of the roots. The peeled roots were diced into chips approximately 1.5 mm in thickness with a Hobart slicer (Model 1612 Hobart Corporation) and re immersed in the 0.5% sodium acid pyrophosphate solution. The chips were then blanched at 90°C for 1 minute in a steam-jacketed pan and dried in an electric air draught oven (Isotemp Oven, Fisher Scientific) at 60°C to constant weight. The dried chips were ground in an electric grinder (Braun Model 1021), passed through a 150-µm mesh sieve, and stored in glass containers at 4°C for further analysis.

Preparation of quinoa flour

Dust and other extraneous particles with a quinoa seeds were removed, after that the seeds were immersed in water 1 hour and washed for 20 min with running tap water in a tank equipped with an agitator. After washing, the seeds were rinsed and tunnel-dried in an electric air draught oven (Isotemp Ove Fisher Scientific) at 50°C for 6 h .The seeds were ground in an electric grinder (Braun Model 1021),with a particle size of 60 mesh sieve, and The flour was mixed with water and the slurry (30% solids) was precooked at 60°C for 20 min and then dried in electric air draught oven (Isotemp Ove Fisher Scientific) at 50°C , The flakes were milled using a cyclone sample mill into meal that could pass through a 60-80 mesh screen and stored in glass containers at 4°C for further analysis, as methods described by Jenny *et al*. (2002) with some modification.

Preparation of germinated pearl millet

The whole grains of pearl millet were immersed in water over night. The grains were spread on trays lined with cloth and kept wet by frequent spraying of water for 72 hrs. The germinated millet (GM) grains were dried and ground to pass sieving 80 meshes described by Eltayeb *et al*. (2007).

Blends formulation of orange flesh sweet potato- pearl millet-quinoa weaning food

Five composite flours were prepared by blending orange flesh sweet potato (OSF), pearl millet (MF), and quinoa (QF) flours in the ratios of 0:100:0(1), 10:60:30(2), 10:50:40(3), 10:40:50(4), 10:30:60(5) and 10:20:70(6).

Preparation of orange flesh sweet potato- pearl millet-quinoa weaning food and **Sensory evaluation**

Weaning foods were prepared according to the method of Opara *et al*., (2012). Weaning foods were prepared by dissolving 50 g of orange flesh sweet potato- pearl millet-quinoa flour blends in 100 mL of clean water. About 150 mL of boiling water was added to the suspension, and this was brought to a boil for 3-5 min, cooled, Samples were served in cups with three-digit random with lids. Sensory analysis was performed by a panel of 20 judges from the staff of the Food Technology Research Institute, Agriculture Research Center, Giza. The panelists were seated in individual booths in a temperature-controlled room at 25°C lighted by daylight fluorescent lights. The sensory analysis of the prepared complementary food gruel was determined using a 9-point hedonic scale, according to the method of Iwe , (2002). Attributes such as colour, aroma, taste, viscosity, and overall acceptability were evaluated.

Analytical methods

The moisture, protein, fat, crude fiber, and ash contents of the PMQ weaning food and the commercial weaning food were determined using the standard methods described by AOAC International (A.O.A.C., 2012). Total carbohydrate was calculated as the difference between 100 and the sum of the percentages of moisture, crude protein, total fat, and ash (Ferris *et al*., 1995). The sample calorific value was calculated from the percentages of crude protein, total carbohydrates, and total fat. The conversion factors used were 4.0 kcal/g for protein and carbohydrates and 9.0 kcal/g for total fat (Buchholz and Schoeller, 2004)**.**

Mineral contents were determined in a dilute solution of th ashed samples according to the method outlined in A.O.A.C., (2012). Amino acid contents were determined by high performance liquid chromatography (HPLC) using the procedure described by Alajaji and El-Adawy, (2006).

Tryptophan content was determined in a separate analysis. Tryptophan analysis was performed by the procedure described by Hariharan *et al*. (1993). The Food and Agriculture Organization/World Health Organization/United Nations University (FAO/WHO/ UNU) reference amino acid pattern for children 6 to 36 months old was used to calculate the essential amino acid score (FAO/ WHO/UNU, 2002). The protein efficiency ratio (PER) was estimated using the regression equation proposed by Alsmeyer *et al.,* (1974) PER = –0.468 +0.454 (leucine) –0.105 (tyrosine). Fatty acids were determined by gas-liquid chromatography with flame ionization detection (GLC-FID)/ capillary column according to the method described by El-Anany and Ali ,(2012). The fatty acid content was monitored by the atherogenic index (AI), calculated by the Ulbricht and Southgate formula cited by Stajić *et al*. (2011).

Storage stability of orange flesh sweet potato- pearl millet-quinoa weaning food

The flour samples of the most acceptable weaning food from sensory evaluation was packed in an air-tight low density polyethylene bag and stored under ambient conditions of (26 ± 2 ºC) for eight weeks. Samples were withdrawn every two weeks and subjected to testing of functional properties such as bulk density, , water absorption capacity , swelling power ,solubility index and ,dispersibility. Chemical composition, such as moisture, free fatty acids, and peroxide value were determined.

Functional properties of orange flesh sweet potato pearl millet-quinoa flour during storage

Bulk density

Bulk density was determined using the method described by Wang and Kinsella, (1976). 10 g of sample was weighed into a 50 mL graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top. The volume of the sample was recorded

Bulk density = Weight of sample / Volume of sample after tapping.

Water absorption capacity

The water absorption capacity of flour was determined using the method described by Ruales and Nair ,(1993). 1 g of sample was suspended in 15 mL of distilled water at 30 ºC in a centrifuge tube and centrifuged at 2500 rpm for 30 minutes. The supernatant was decanted and the weight of the

formed gel was recorded. The water absorption capacity (WAC%) was calculated as percentage of bound water in gel weight .
WAC% = (Gram of bound water / Weight of sample)×100.

Swelling power and Solubility index

The swelling power and solubility index were determined using the method described by Takashi and Sieb ,(1988). 1 g of flour was weighed into a 50 mL centrifuge tube. 50 mL of distilled water was added and mixed gently. The slurry was heated in a water bath at 90 ºC for 15 minutes. During heating, the slurry was stirred gently to prevent clumping of the flour. On completion, the tube containing the paste was centrifuged at 3,000 rpm for 10 minutes. The supernatant was decanted immediately after centrifuging. the weight of dry solid in supernatant was determined after drying the supernatant .The weight of the sediment was taken and recorded. The moisture content of sediment gel was thereafter determined to get the dry matter content of the gel **.**
Swelling power (g/g) = Weight of mass of sediment / Weight of dry matter in the gel

Solubility index % = (Weight of dry solids in supernatant after drying / Weight of sample) × 100

Dispersibility

Dispersibility was determined by the method described by Kulkarni *et al*. (1991). 10 g of flour was suspended in a 100 mL measuring cylinder and distilled water was added to reach a volume of 100 mL. The setup was stirred vigorously and allowed to settle for 3 hours. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersibility.

Moisture content

The moisture content of the flour was determined using the method described by A.O.A.C., (2012).

Free Fatty Acids

Free fatty acids were determined according to the method of Sani, (2015). 2.0 g of the flour was transferred into a 250 cm3 Erlenmeyer flask followed by the addition of 100 cm3 of ethanol and 2 cm3 of phenolphthalein indicator. After mixing the content properly, it was titrated against 0.04 M NaOH. The shaking continued until a slight pink colour was observed, which was steady for about 30 seconds and signified the end point.The% of free fatty acids was calculated using Equation

$$FFA\% = V \times N \times 28.2 / W$$

Where :
FFA% = percentage of free fatty acids,
V= average volume of NaOH used (cm3), N = normality of NaOH,
W = weight of the flour sample.

Peroxide value

The peroxide value was determined using the method described by Sani, (2015). 2.0 g of the flour sample was weighed into a clean dry flask and 22 cm3 of the mixture of 10 cm3 of acetic acid and 12 cm3 of chloroform was added, then 0.5 cm3 of potassium iodide was also added. The flask was closed and allowed to stay with constant shaking for 1 minute. 30 cm3 of distilled water was then added and titrated against 0.1 M of sodium thiosulphate (Na2S2O3) solution until an initial yellow colour disappeared and a faint blue colour appeared. The titration continued after the addition of 0.5 cm3 of starch indicator until there was a sudden disappearance of the blue colour, which signifies the end point. Thus, peroxide value was calculated using Equation 2
Peroxide value (mEq/kg) = (S-B) ×N×1000 / W.
where:
peroxide value= mEq of peroxide per Kg of sample, S=sample titre value (ml), B=blank titre value (ml), N= normality of Na2S2O3, W=weight of flour (gm).

Statistical analysis

Statistical analysis was carried out according to Fisher, (1970). LSD (Least significant difference) test was used to compare the significant differences between means of treatment (Waller and Duncan, 1969).

Results and Discussion

1- Composition and caloric content of the ingredient of PMQ

The chemical composition and caloric content of orange-fleshed sweet potato flour, germinated-pearl millet and precooked quinoa are presented in Table 1. It is clear from the results that, the moisture contents of the materials used to formulate the PMQ weaning food varied from 68.65% to 7.21%. Moisture content and water activity are key factors affecting: the storage, shelf life, and safety of foods (Gustavo *et al*., 2008). The moisture content of germinated pearl millet flour was 7.21g/100g and energy content was 358.84kcal.

Table 1: Chemical composition and caloric content of the ingredients of the PMQ (on dry weight basis)

Nutrient %	OSP	OSPF	Pearl millet	Germinated Pearl millet	Quinoa	Precooked quinoa
Moisture	68.65	7.89	10.65	7.21	9.10	7.32
Protein	5.92	5.89	12.10	13.09	15.64	16.40
Fat	1.02	0.99	5.54	3.35	5.85	5.93
Fiber	2.46	1.97	2.22	2.28	3.97	2.37
Ash	3.35	3.05	2.35	2.38	3.52	2.27
Carbohydrate	87.25	88.1	77.79	78.90	71.02	73.03
Energy (kcal)	381.86	384.87	373.12	358.84	399.29	411.09
Minerals mg/1oo gm						
Ca	143.45	122.68	49.24	76.52	96.15	89.55
P	446.57	222.56	442.08	387.97	52.26	43.93
F	2.72	2.31	11.53	16.49	7.26	6.72
Zn	1.74	1.69	3.16	5.65	3.41	5.05
βeta-carotene mg/1oo gm	7.75	9.31	1.79	4.86	0.54	0.46

The Protein, Carbohydrate, Iron, calcium, beta-carotene and zinc values per 100 g of germinated pearl millet flour were 13.09 g, 78.90g , 16.49 mg, 76.52 mg, 4.86 mg and 5.65mg, respectively which were higher than the values of the raw pearl millet**;** whereas the fat content (3.35g/100g) was lower. Nnam (2000) and Akpapunam *et al*., (1996) reported an increase in the protein contents of various cereals and legumes during the germination and fermentation processes. This increase during the germination process can be attributed to the synthesis of enzyme protein by germinating seeds (WHO, 1998, Nzeribe & Nwasike, 1995). It is also clear from the results that ,precooked quinoa had the highest level of protein (16.40%). (Lilian, 2009) found that the mean protein contents reported in the literature for quinoa seed is 12–23%. Orange-fleshed sweet potato flour had adequate amount of protein (5.89 %).

The fat contents of the samples were**:** 5.93%, 3.35% and 0.99 %, for precooked quinoa, germinated- pearl millet and orange-fleshed sweet potato flour, respectively. (Koziol, 1992) found that, the fat content of quinoa is 5.6%. The fiber contents were 2.37%, 2.28%, and 1.97% for precooked quinoa, germinated- pearl millet and Orange-fleshed sweet potato flour, respectively.

Orange-fleshed sweet potato flour had highest level of ash; at 3.05% where the higher ash contents of orange-fleshed sweet potato flour indicates a higher mineral content. The Germinated Pearl millet had a moderate amount of minerals as stated by (Klopfenstein and Hoseney, 1995). The Germination process of millets (*Pennisetum typhoides*) improved the in vitro protein (14% to 26%) and starch digestibility (86% to 112%) (Shahidi and Chandrasekara, 2013). The *in vitro* extractability and bio-accessibility of minerals such as calcium, iron and zinc were increased in pearl and finger

millets by the germination process (Krishnan *et al*., 2012).

The highest levels of carbohydrate were recorded with orange-fleshed sweet potato flour, at 88.10%,while precooked quinoa and germinated- pearl millet contained a moderate amount of carbohydrate (73.03% and 78.90%) respectively.

Orange-fleshed sweet potato flour had a high level of carotenoids, 9.31mg/100 g dry weight. Orange fleshed sweet potato flour is an excellent source of bioavailable β- carotene. β-Carotene is the carotenoid with the highest pro vitamin A activity (100%) because it can be entirely converted into two molecules of vitamin A (retinol) (Bechoff, 2010). All-trans-β-carotene constitutes about 80% to 90% of the total carotenoids in orange-fleshed sweet potato flour (Bengtss et. al., 2008). The germination of millet improved the β-carotene contents from1.79 to 4.86 mg/100g, and improved minerals and protein contents and their availability where these results were in agreement with those given by Grewal and Jood, (2006)

2- Amino acid composition of the ingredients of PMQ

The Nutritional Quality of any protein is principally governed by its amino acid composition. Table (2) shows the amino acid composition of: orange-fleshed sweet potato flour, germinated-pearl millet and precooked quinoa.

Table 2: Amino acids composition of orange-fleshed sweet potato flour, germinated Pearl millet and precooked quinoa

Amino acids	(g/100g protein)				
	Orange sweet ptato flour	Germinated Pearl mellit	Precooked quinoa	FAO/WHO/UNU* reference protein	
				0.5–1 yr	1–2 yr
Essential amino acids					
Lysine	5.40	2.99	5.82	5.7	5.20
Leucine	6.87	11.65	6. 78	6.60	6.30
Isoleucine	3.94	4.69	4.36	3.20	3.10
Threonine	5.73	4.46	4.44	3.10	2.70
Histidine	3.95	2.65	3.37	2.00	1.80
Valine	6.78	6.54	4.82	4.30	4.20
methionine	1.93	2.87	3.82		
Cysteine	1.98	1.28	1.98		
Total sulfur amino	3.91	4.15	5.80	2.80	2.60
phenylalanine	5.20	5.34	3.79		
tyrosine	3.21	2.80	5.60	3.10	2.70
Totl aromatic amino acids (tyr+phe)	8.41	8.14	9.35	5.20	4.60
Tryptophan	0.91	2.04	1.15	0.85	0.74
Total essential amino acids	45.90	47.31	45.89		
Nonessential amino acids					
Glutamic acid	14.57	16.1	16.13		
Aspartic acid	16.86	9.74	10.67		
Proline	3.81	4.93	3.71		
Arginine	4.32	4.46	7.80		
Glycine	4.71	3.45	4.92		
Alanine	3.93	9.86	5.68		
Serine	5.90	4.15	5.20		
Total nonessential amino acids	54.10	52.69	54.11		
PER	2.31	4.53	2.02		

*FAO/WHO/UNU reference protein for children 0.5 to 1 and 1 to 2 years of age , Geneva, Switzerland, (2002).

The formed essential amino acids were 45.90 %, 47.31% and 45.89% of orange- fleshed sweet potato flour, germinated-pearl millet and precooked quinoa, respectively. Quinoa is found comparable to that of milk protein where the presence of both lysine (5.82%) and methionine (3.82%) gives it a unique feature and makes it a complete food **(**USDAU.S, 2005**).** Quinoa has a good balance of the amino acids that make up the protein. It is exceptionally high in lysine, an amino acid which is not overly abundant in the vegetable kingdom. It is also a good complement for legumes which are often low in methionine and cysteine. The Protein Efficiency Ratio (PER) in raw debittered quinoa is 78%–93% that of casein. These figures increase when quinoa is cooked and become 102%–105% of those of casein (Valencia-Chamorro, 2003).

The results also show that germinated-Pearl millet has been found to contain high levels of essential amino acids i.e. 47.31%, where it particularly contains amino acids of Leucine at 11.65%. Malting induces important beneficial bio-chemical changes in the millet grain. Moreover, soaking generates grain softening and increases water absorption. The enzymes produced during the germination process are responsible for the hydrolysis of starch and proteins, which makes sugar and peptides/amino acids directly available. Furthermore, protolithic enzymes improve the availability of limiting amino acids such as lysine, methionine, and tryptophan (Badau *et al.,* 2005). The Germination and probiotic fermentation processes significantly improved the contents of thiamine, niacin, total lysine, protein fractions, sugars, soluble dietary fiber (Arora *et al.,* 2011). In comparison to sorghum and maize, pearl millet contains higher amounts of lysine (Ejeta *et al.,* 1987).

Table (2) also shows that the Non-essential amino acids represented in orange-fleshed sweet potato flour, germinated-pearl millet and precooked quinoa at 54.17%, 52.69% and 54.11% respectively of the total amino acid contents. Arginine, aspartic acid, and glutamic acid were the major nonessential amino acids in precooked quinoa, with contents of 7.80%, 10.67%, and 16.13%, respectively whereas, aspartic and glutamic acids were the major non-essential amino acids in orange-fleshed sweet potato flour protein, with contents of 16.86% and 14.57%, respectively.

3-Chemical composition of the PMQ weaning food.

The Nutritional compositions of the PMQ weaning food are presented in Table (3). PMQ weaning food has been made using sweet potato flour, germinated pearl millet and precooked quinoa which were suitably processed into flours using home processing.

Table 3: Chemical composition of the PMQ weaning food(on dry weight basis)

Nutrient %	OP:M:Q 0:100:0(1)	OP:M:Q 10:60:30(2)	OP:M:Q 10:50:40(3)	OP:M:Q 10:40:50(4)	OP:M:Q 10:30:60(5)	OP:M:Q 10:20:70(6)
Moisture	7.21	7.32	7.61	7.21	7.35	7.29
Protein	13.09	13.51	13.65	13.88	14.19	14.57
Fat	3.35	3.79	4.06	4.32	4.58	4.84
Fiber	2.28	2.23	2.22	2.17	2.27	2.30
Ash	2.38	2.73	2.29	2.27	2.26	2.28
Carbohydrate	78.90	77.74	77.78	77.36	76.7	76.01
Energy (kcal)	398.11	399.11	402.26	403.84	404.78	405.88
Minerals mg/1oo gm.						
Ca	88.37	95.98	86.46	86.98	87.89	89.65
P	387.97	269.21	233.36	197.98	148.08	111.11
F	16.49	12.35	10.95	9.83	8.86	7.92
Zn	5.65	4.95	4.83	4.21	4.74	4.81
beta-carotene mg/1oo gm.	4.86	3.83	3.49	3.36	2.40	2.19

The processed formulas P:M:Q (0:100:0 (1), 10:60:30 (2), 10:50:40 (3), 10:40:50 (4), 10:30:60 (5) and 10:20:70 (6)) were analyzed. The proximate compositions of the PMQ are shown that, the control of germinated pearl millet without sweet potato, and precooked quinoa substitution had the highest P, F and Z contents of 387.97, 16.49 and 5.65mg/100g respectively. The increase of Protein and fat content is as a result of addition of precooked quinoa. Moisture ranged between 7.21– 7.61% in blends. Protein, Fat, and Energy values found to be 14.57, 4.84% and

405.88 (kcal), respectively in PMQ (10:20:70) blend (6) which were higher than those of the other blends.

4-Sensory properties of the PMQ weaning food

Table (4) shows the mean sensory scores of the weaning food made from the flour blends of orange flesh sweet potato, germinated Pearl millet and precooked quinoa**.** The aroma of PMQ weaning food ranged from 7.33 to 8.27. Sample (10:30:60) blends (5) had the highest value for aroma, while samples 0:100:0 (1) and 10:60:30 (2) had the lowest.

The taste and color of (PMQ) weaning food ranged from 7.10 to 8.60 and 6. 93 to 8.67 respectively. Sample (PMQ) 10:30:60 (5) had the highest value for taste, while sample 0:100:0 (1) had the lowest value for taste. Sample 10:20:70 (6) had the highest value for color; while sample 0:100:0 (1) had the lowest value for color. The viscosity of PMQ weaning food ranged between (6.80 and 8.33). The overall acceptability expresses how the consumer or the panelists generally accept the product so it was observed that PMQ weaning at 10:30:60 blend (5) was highly accepted. This could be due to the familiarity of taste, aroma, and color. The results provide a basis for the development of an acceptable weaning food that can provide the required protein and energy levels that are essential basic nutrients to enable the accomplishment of a day's work (Bilsborough and Mann, 2006).

Table 4: Mean score for sensory properties of the PMQ weaning food

OP:M:Q	Aroma(9)	Taste(9)	Colour(9)	Viscosity(9)	Overall acceptability(9)
0:100:0(1)	7.33 ±.21c	7.10 ±.20d	6. 93±.25d	7.93±.15b	7.33±.05d
10:60:30(2)	7.53 ±.21bc	7.63 ±.15c	7.53 ±.15c	6.80 ± .17d	7. 38±.18d
10:50:40(3)	7.63±.15 bc	7.80 ±.30c	7.73±.21c	7.10±.10d	7.57±.08c
10:40:50(4)	7.80±.10b	8.20 ±.10b	8.20 ±.10b	7.50 ±.10c	7.91±.02b
10:30:60(5)	8. 27± .58a	8.60 ± .26a	8.60 ±.26a	8.33 ±.21a	8.43±.11a
10:20:70(6)	7.67±.21b	8.33±.16ab	8.67±.58a	7.93±.25b	8.15±.10a

Means with the same column followed by the same letter are not significantly different ($p < .05$)

5- Chemical composition of PMQ 10:30:60 and commercial weaning food

The Nutritional Compositions of a chosen PMQ weaning food, (PMQ weaning at (10:30:60) blend (5) and the commercial weaning food are presented in Table (5). The moisture contents of the PMQ weaning food and the commercial weaning food were 7.45% and 6.40 %, respectively. Monitoring the moisture contents in foods and food products is crucial because high moisture contents can reduce the shelf life by increasing the microbial degradation activity, resulting in bad odor and un-acceptable product taste (Olu-Owolabi *et al*., 2007).

Table 5: Nutrient composition of the PMQ 10:30:60 weaning food and the commercial weaning food (Cerelac) (g/100 g on dry weight)

Nutrient %	**P:M:Q 10:30:60 (5)**	**Cerelac**	**Codex standard**
Moisture	7.35	6.40	< 5
Protein	14.19	16.24	15
Fat	4.58	10.15	10–25
Fiber	2.27	1.82	< 5
Ash	2.26	2.99	< 3
Carbohydrate	76.7	68.8	60–75
Energy (kcal)	404.78	431.51	400–425
Minerals mg/1oo gm			
Ca	87.89	633.76	500
P	148.08	471.05	456
F	8.86	7.92	16
Zn	4.74	2.51	3.20
Betacaroten mg/1oo gm	2.40	1.26	

CODEX CAC/GL 08. Codex, (1991).

According to Egyptian Standard No. 3284 (2005), the recommended moisture contents of the infant formula are not more than 7%. However, the moisture contents of the PMQ product was slightly higher than the maximum level recommended by the Codex Standard for the infant formula (Codex Standard 71-1982).

Protein is the principal component of the body tissues. The protein contents of the PMQ weaning food was 14.19 g/100 g dry weight where this value was lower than that of the commercial weaning food and the protein value stipulated in the Codex Standard (CODEX CAC/GL 08, 1991) by 12.62% and 5,40 %, respectively. The formulated weaning food complies with both the permitted levels (15%) of Food and Nutrition Board (1989) and with the Egyptian Standard No. 3284, (2005).

The fat contents of the PMQ weaning food and the commercial weaning food were 4.58% and 10.15%, respectively.

The crude fiber contents of the PMQ weaning food and the commercial product were 2.27% and 1.82%, respectively. The fiber contents of the weaning food should be reduced to a level of not more than 5 g/100 g (CODEX CAC/GL 08, 1991).

The Ash content is an important parameter that may be used to evaluate the authenticity of food products (Egyptian Standard No. 3284, 2005). The ash contents of the PMQ weaning food and the commercial weaning food were 2.26% and 2.99%, respectively. The ash content in vegetarian baby food fortified with milk should not be more than 3% as recommended by the Egyptian Organization for Standardization (Egyptian Standard No. 3284, 2005).

Carbohydrate is the main source of energy in the human body where the carbohydrate contents of the PMQ weaning food and the commercial weaning food were 76.7and 68.8g/100 g dry weight, respectively. The Food and Nutrition Board of the National Research Council, (1989) reported that more than half of the energy requirements beyond infancy should be provided by carbohydrates, with emphasis on complex carbohydrates rather than sugars.

Adequate intakes of micronutrients such as iron, zinc, and calcium are important for ensuring optimal health, growth, and development of infants and young children (Huffman *et al*., 1994). The mineral contents of the PMQ weaning food and the commercial weaning food are presented in table 5. Calcium and Phosphorus constituted the major minerals in the PMQ weaning food, with levels of 87.89and 148.08 mg/100 g dry weight, respectively. The PMQ weaning food had limited amounts of iron and zinc: 8.86 and 4.74 mg/100 g dry weight, respectively, but more than commercial weaning food. Cereals and legumes are important sources of iron, zinc and calcium for rural infants and children (Sanny *et al*., 2007).

6- Amino acids content and PER values of PMQ 10:30:60 and commercial weaning food

Table (6) Shows the amino acid compositions of the PMQ weaning food and the commercial weaning food. The following nine amino acids have been identified as essential for infants: threonine, valine, leucine, isoleucine, lysine, tryptophan, phenylalanine, methionine, and histidine. Arginine and cysteine are also essential for low-birth weight infants (Behrma and Vaughan, 1983). All of the essential amino acids as well as the nonessential ones were detected. Essential amino acids accounted for 46.31% of the total amino acid contents of the PMQ complementary food The essential amino acid contents of the PMQ weaning food were higher than the amino acid profile of the FAO/WHO/UNU reference protein for children (0.5 to 1) and (1 to 2) years of age except lysine content.

Table (6)also showed that the non-essential amino acid content of the PMQ weaning food represented 53.69% of the total amino acid contents. Aspartic acid and glutamic acid were the major non-essential amino acids in the protein of the PMQ weaning food, at 11.03%, and 15.97%, respectively. The Protein Efficiency Ratios (PER) of the PMQ product and the commercial product were 2.80 and 2.42, respectively.

7-Fatty acids profile of PMQ 10:30:60 and commercial weaning food

Fatty Acids play important roles in the Biological Systems. These fatty acids are the constituents of the lipids in the biological membranes that influence the membrane properties such as fluidity, integrity, permeability and the activities of the membrane-bound enzymes (Stubbs and Smith, 1984). The fatty acid profiles of the PMQ product and the commercial product are given in Table (7).

Generally speaking, the level of polyunsaturated fatty acids was higher in the PMQ Weaning Food (50.56%) than in the commercial weaning food 24.70%. On the other hand, the level of saturated fatty

acids was higher in the commercial weaning food 51.00 % than in the PMQ weaning food 27.21%. A high proportion of un-saturated relative to saturated fatty acids in food is desirable because of the health benefits of the un-saturated fatty acids (Coultate, 2002).

A moderate level i.e. (5.26) of linolenic acid was detected in the PMQ product while a low level i.e. (0.60%) of linolenic acid was detected in the commercial product. The recommended intake of α-linolenic acid (18:3 n 3) is from 1.0 to 2.4 g/day (Lanzmann, 2001).

The most prominent fatty acids in the PMQ weaning food were Linoleic acid (44.13%), Oleic acid (19.75%) and palmitic acid (23.62%); the commercial weaning food had high levels of palmitic acid (35.10%), oleic (24.3%), and linoleic (24.10%). Linoleic acid (18:2) is one of the omega-6 or n-6 fatty acids are required by humans but cannot be made in the human body and therefore, it is considered essential in the diet. Linoleic acid is the precursor of arachidonic acid, which is a substrate for eicosanoid production, which is involved in the regulation of gene expression (Ou *et al*., 2001).

Both n-6 and n-3 fatty acids have been shown to have anti-inflammatory properties that are protective against atherogenic changes in vascular endothelial cells (De Caterina *et al*., 2000).

Table 6: Amino acid profile and protein efficiency ratio (PER) of the PMQ 10:30:60 weaning food and the commercial weaning food (Cerelac) (g/100 g protein)

Amino acids	(g/100g protein)			
	PMQ 10:30:60	Cerelac	FAO/WHO/UNU reference protein	
			0.5–1 yr	1–2 yr
Essential amino acids				
Lysine	4.86	3.22	5.70	5.20
Leucine	8.25	7.08	6.60	6.30
Isoleucine	4.44	4.20	3.20	3.0
Threonine	4.58	2.3	3.10	2.70
Histidine	3.23	2.21	2.00	1.80
Valine	5.54	6.67	4.30	4.20
Methionine	3.35	3.30		
Cysteine	1.77	2.37		
Total sulfur amino	5.12	5.67	2.80	2.60
Phenylalanine	4.38	4.12		
Tyrosine	4.52	3. 13	3.10	2.07
Totl aromatic amino acids (tyr+phe	8.90	7.25	5.20	4.60
Tryptophan	1.39	0.79	0.85	0.74
Total essential amino acids	46. 31	39.39		
Nonessential amino acids				
Glutamic acid	15.97	18. 16		
Aspartic acid	11.03	11.40		
Proline	4.09	4.49		
Arginine	6.46	8.32		
Glycine	4.46	5.85		
Alanine	6.72	6. 94		
Serine	4.96	5.45		
Total nonessential amino acids	53.69	60.61		
PER	2.80	2.42		

FAO/WHO/UNU reference protein for children 0.5 to 1 and 1 to 2 years of age , Geneva, Switzerland, (2002).

Table 7: Fatty acids profile of t the PMQ 10:30:60 weaning food and commercial weaning food (Cerelac) (g/100 g oil)

Fatty acids	PMQ(5)	Cerelac
C 14 Myristic acid	0.20	9.05
C 16 Palmitic acid	23.62	35.10
C 16:1 Palmitoleic acid	0.16	ND
C 16:3	0.94	ND
C 18 Stearic acid	1.87	6.85
C 18:1 Oleic acid	19.75	24.3
C 18:2 Linoleic acid	44.13	24.10
C18:3 Linolenic acid	5.26	0.60
C 19 Nanodecylic acid	0.81	ND
C20 Arachidic acid	0.43	ND
C 20:1 Gadolenic acid	0.16	ND
C20:2Eicosadienoic acid	0.23	ND
C24 Tetracosanoic acid	0.28	ND
C24:1Tetracosenoic acid	2.16	ND
Total Saturated fatty acids	27.21	51.00
Monounsaturated fatty acids	22.23	24.3
Polyunsaturated fatty acids	50.56	24.70

8- Sensory evaluation of the PMQ 10:30:60 and commercial weaning food

Sensory Evaluation of the PMQ baby food formulas was considered as one of the important tests affecting, to a large extent, their acceptability (Tawfik, 1999). Table (8) shows the results of a sensory evaluation of the PMQ weaning food and the commercial weaning food (Cerelac).

There were differences between the commercial and the PMQ product in aroma, taste, color, viscosity and overall acceptability where the overall acceptability of the commercial product was greater than that of the PMQ product. This could be because of flavoring, sweetening, and other sensory-enhancing agents which are incorporated into the commercial products during its formulation (Ijarotimi, 2008). The sensory evaluation results show that the PMQ weaning food may be considered acceptable with regard to its aroma (7.20), taste (7.37), color (7. 63), Viscosity (6.90) and overall acceptability (7.28). The current study recommends adding natural flavors or sweeteners during the preparation of the PMQ weaning food to increase its palatability and acceptability

Table 8: Sensory evaluation of the PMQ 10:30:60 weaning food and the commercial weaning food (Cerelac)

Food	Aroma(9)	Taste(9)	Colour(9)	Viscosity(9)	Overall acceptability(9)
PMQ10:30:60	7.20±0.10b	7.37 ±.06b	7. 63±.26b	6.90±.26b	7.28±.13b
Cerelac	8.071±.15a	8.4 ± .20a	8.50 ±20a	8.5 ±.20a	8.38±.11a

Values are means ± SD. Means in the same column followed by the same letter are not significantly different ($p < .05$)

9 - Functional properties of the PMQ 10:30:60 during storage for 8 weeks

The Functional Properties of the PMQ (10:30:60) weaning food during storage were shown in Table(9) where the functional properties determine the application and use of food materials for various food products.

The results obtained during the storage period show that there were differences in: dispersibility, power, solubility, and water absorption capacity of sample (10:30:60) during its storage. The bulk density of the flour ranged from (0.55 to 0.0.61) g/mL, at zero time of storage having the lowest, whereas week (8) had the highest. The bulk density obtained during the period of storage in this study was very low and this indicates that the flour sample would be an advantage in the preparation of weaning foods. Akpata and Akubor, (1999) reported that the bulk density is influenced by the particle size and the density of the flour, and that it is important in determining the packaging requirements and the material handling. Karuna *et al*., (1996) and Plaami, (1997) reported

that bulk density is influenced by the structure of the starch polymers and the loose structure of the starch polymers could result in low bulk density. The bulk density is a measure of heaviness of the flour sample which gives an indication that the relative volume of the composite flour in a package will not be reduced excessively during storage.

Table 9: Functional properties of the PMQ 10:30:60 weaning food during storage

Weeks	Bulk density(g/mL	Water absorption capacity (%)	Swelling power(g/g)	Solubility index (%)	Dispersibility (%)
0	0.55	92.77	4.32	3.56	85.00
2	0.58	83.22	4.18	3.33	82.50
4	0.59	80.56	3.99	3.16	74.50
6	0.60	79.10	3.86	2.90	70.50
8	0.61	73.30	3.79	2.90	67.00

The dispersibility of PMQ (10:30:60) weaning food ranged between 67.00% and 85.00%. It had lower dispersibility during storage at (8) weeks, but had higher dispersibility at zero time of storage. Dispersibility is a measure of the reconstitutability of the flour or flour blends in water. The higher the dispersibility, the better the flour reconstitutes in water (Kulkarni *et al*., 1991). However, since the dispersibility value for the flour samples during the storage is relatively high, it implies that the flour sample will reconstitute easily to give fine consistency dough during mixing, as reported by Adebowale *et al*., (2011).

Swelling power connotes the expansion accompanying the spontaneous uptake of a solvent; while the solubility index is the amount of water soluble solids per unit weight of the sample (Adepeju *et al*., 2014). The swelling power and solubility index of PMQ (10:30:60) weaning food decreased, ranging from 4.32 to 3.79 g/g and 3.56 to 2.9 %, respectively. The swelling power and solubility index of PMQ (10:30:60) weaning food during storage had the lowest value at (8) weeks but the PMQ (10:30:60) weaning food had the highest swelling power and solubility index during storage at zero time of storage .(Kinsella ,1976) reported that swelling causes changes in the hydrodynamic properties of the food, thus impacting characteristics such as body thickening and increased viscosity of foods. This implies that the flour blend (sample 10:30:60) with the highest swelling power during the period of storage at zero time of storage will produce a thick viscous gruel, compared to other weeks of storage. This might be due to the higher carbohydrate contents in PMQ (10:30:60) weaning food.

Water absorption capacity is the ability of flour to absorb water and swell so as to improve consistency in food. It is desirable for food systems to improve yield and consistency and to give body to the food (Osundahunsi *et al*., 2003). The water absorption capacity during the period of storage ranged from 92.77% to 73.30%. PMQ (10:30:60) weaning food sample had the lowest swelling power during storage at (8) weeks i.e. 3.79%, whereas it had the highest swelling power at zero time i.e. (4.32 g/g). The values of the water absorption capacity obtained for the flour sample during the period of storage correspond with the swelling power and solubility. This implies that the low water absorption capacity of the flour blend (sample 10:30:60) obtained in this work during the period of storage will be desirable for making thinner gruel with high caloric density per unit value which in turn is in agreement with Adepeju *et al*. (2014).

10- Storage stability of PMQ 10:30:60 weaning food.

Storage Stability of PMQ (10:30:60) weaning food is presented in Table (10) where the Moisture contents of the flour sample was within the acceptable limit of not more than 10% for the long storage of flour.

The results obtained for the moisture contents of the flour sample during storage shows that there was a gradual uptake of moisture by all the flour samples throughout the storage period. The increase in moisture contents of the stored flour sample could be attributed to the storage conditions such as temperature, relative humidity, time, and the packaging material (high density polyethylene), which allows the movement of certain gases across the material (Daramola *et al*., 2010). The moisture

contents of the flour sample ranged between 7.35% and 9.22% where the moisture content is a function of the drying time and the loading depth during the drying operation. Higher moisture contents indicate increased susceptibility to spoilage and thus reduce the shelf life.

Free Rancidity is accompanied by free fatty acids and the formation, i.e. spoilage of the flour, and is used as a condition for edibility. Free fatty acids of the flour samples ranged from 1.12% to 3.19%. PMQ (10:30:60) weaning food sample had the highest free fatty acids during storage at (8) weeks. The results obtained in this study show that the low obtained free fatty acids value is an indication of the long storage period in the flour sample.

Table 10: Storage stability of PMQ 10:30:60 weaning food

Weeks	Moisture content (%)	Free fatty acids (%)	Peroxide value (meq/kg)
0	7.35	1.12	0.07
2	8.12	2.26	0.08
4	8.60	2.68	1.05
6	8.81	2.91	1.14
8	9.22	3.19	1.23

Peroxide value is usually used as an indicator of the deterioration of fats. As oxidation takes place, the double bonds in the unsaturated fatty acids break down to produce secondary oxidation products which indicate rancidity (Ihekoronye and Ngoddy, 1985). The peroxide value during the period of storage ranged from 0.07 to 1.23 meq/kg. PMQ (10:30:60) weaning food sample had the highest peroxide value during storage at (8) weeks, whereas it had the lowest peroxide value during storage at zero time. During storage, the peroxide value increased as the storage period increased where this was in agreement with the observation of Gahlawat and Sehgal, (1994) that the peroxide value and fat acidity of weaning food developed from locally available food stuffs increased with the increase in the storage period**.**

Conclusions

This study shows that weaning food can be produced from**:** the orange-fleshed sweet potato flour, germinated-pearl millet and precooked quinoa**;** however, the flour blend of sample (10:30:60) was the most acceptable in terms of all the sensory attributes for the weaning food. It can be deduced from the results that during the storage days of the flour blend sample (10:30:60) the dispersibility and water absorption capacity of the flour blend had a higher affinity for water and has chemical composition accept**.**

References

Adebowale, A.A., L.O. Sanni, and E.L. Fadahunsi, 2011. Functional and pasting properties of cassava sweet potato starch blends. Afri. J. of Root and Tuber Crops 9: 1-6.

Adepeju, A.B., S.O. Gbadamosi, T.O. Omobuwajo and O.A. Abiodun, 2014. Functional and physicochemical properties of complementary diets produced from breadfruit (*Artocarpus altilis*). Afri. J. of Food Sci. and Technol. 5 (4): 105-113.

Agugo, U.A., M. Nwogwugu, S. Sunday, N.P. Uchegbulem, and C.A. Ariwaodo, 2013. Chemical and microbial qualities of weaning food produced from mungbean(Vigna radiata) and maize (Zea mays)) , Central European Journal of Experimental Biology. 2 (3):34-39

Ahamed, T., R .Singhal, P. Kulkarni and M .Pal, 1998. A lesser-known grain, *Chenopodium quinoa*: Review of the chemical composition of its edible parts. Food Nutr. Bull. 19: 61–70.

Akoma, O., E.A. Jiya, D.D. Akumka and E. Mshelia, 2006. Influence of malting on the nutritional characteristics of kunun-zaki. Afr. J. Biotechnol. 5:996 -1000

Akpapunam, M.A., S.O. Igbedioh and I. Aremo, 1996. Effect of malting time on chemical composition and functional properties of soybean and Bambara ground nut flours. Int. J. Food. Sci. Nutr., 46: 27-33

Akpata, M.I. and P.I. Akubor, 1999. Chemical composition and selected functional properties of sweet orange (*Citrus sinesis*) seed flour. Plant Food Human Nutr., 54: 353-362

Alajaji, S.A. and T.A. El-Adawy, 2006.Nutritional composition of chickpea (*Cicer arietinum* L.*)* as affected by microwave cooking and other traditional cooking methods. J. Food Compos Anal,19:806–812.

Allen, L.H and S.R. Gillespie, 2001. What works? A review of the efficacy and effectiveness of nutrition interventions. Manila: United Nations Administrative Committee onCoordination (ACC) and Sub-Committee on Nutritionin collaboration with the Asian Development Bank,

Allen, L. H., 2003. Interventions for Micronutrient Deficiency Control in Developing Countries: Past, Presentand Future. Journal of Nutrition, 133 (11 Supple 2):3875-3878.

Alsmeyer, R.H., A.E. Cunningham and M.L. Happich, 1974. Equations predict PER from amino acid analysis. Food Technol, 28:34–40.

AOAC, 2012. Official Methods of Analysis. Association of Official Analytical Chemists 19th edition, Washington D.C., USA.

Arora, S., S. Jood and N. Khetarpaul, 2011. Effect of germination and probiotic fermentation on nutrient profile of pearl millet based food blends. Br. Food J., 113(4): 470-481.

Badau, M.H., I. Nkama and I.A. Jideani, 2005. Phytic acid content and hydrochloric acid extractability of minerals in pearl millet as affected by germination time and cultivar. Food Chem., 92 : 425–435

Bechoff, A., 2010. Investigating carotenoid loss after drying and storage of orange-fleshed sweet potato. PhD thesis, University of Greenwich, UK,

Behrma, R.and V. Vaughan, 1983 . Nutrition and nutritional disorders.In: Nelson W, ed. Nelson textbook of pediatrics, 12th Ed. Philadelphia, PA, USA,:138–139.

Bengtss, A., A. Namutebi, M.L. Alminger and U. Svanberg, 2008. Effects of various traditional processing methods on the all-trans-β-carotene content of orange fleshed sweet potato. J Food Compos Anal., 21:134-143

Bhargava, A., S. Shukla, D. Ohri, 2006. Chenopodium quinoa-an indian perspective. Industrial Crops Prod., 23: 73-87.

Bilsborough, S. and N.J. Mann, 2006. A review of issues of dietary protein intake in human. Int. J. Sport Nutr. Exercise metabolism, (16): 129-152.

Bonsi, E. A., W. A. Plahar, and R. Zabawa, 2014.: Nutritional enhancement of Ghanaian weaning foods using the orange flesh sweet potato (*Ipomea batatas*). Afr. J. Food. Agric. Nutr. Dev. ,14 (5):2036-2056

Buchholz, A.C.and D.A. Schoeller, 2004. Is a calorie a calorie? Am J Clin Nutr;79(suppl):899S–906S.

CODEX CAC/GL 08. Codex, 1991. Alimentarius: Guidelineson formulated supplementary foods for older infants and young children. Vol 4. Rome: FAO/WHO Joint Publications,:144.

Codex Standard 71-,1982. Codex standard for infant formula. www.Euro.who.int

Comai, S., A. Bertazzo, L. Bailoni, M. Zancato, C.V.L Costa and G. Allegri, 2007. The content of proteic and nonproteic (free and protein-bound) tryptophan in quinoa and cereal flours. Food Chemistry, 100(4): 1350-1355.

Coultate, T.P., 2002. Food: The chemistry of its components, 4th Ed. Cambridge, UK: Royal Society of Chemistry.

Daramola, O.A., M.A. Idowu, O.O. Atanda and C.R.B. Oguntona, 2010. Effects of packaging material on the quality of "pupuru" flour during storage. Afri. J. Food Sci., 4 (11): 112-127.

Dayakar, R. B., K.Bhaskarachary,C. G.D.Arlene, D. G.Sudha, A. Tonapi, 2017. Ntritional and Health benefits of Millets. ICAR_Indian Institute of Millets Research (IIMR) Rajendranagar, Hyderabad, PP 112.

De Caterina, R., J.K. Liao and P. Libby, 2000. Fatty acid modulation of endothelial activation. Am. J. Clin. Nutr.,71(1suppl):213–223

Egyptian Standard No. 3284., 2005.Processed cereal-basedfoods for infants and children. Cairo: Egyptian Organization for Standardization and Quality Control, Ministry of Industry.

Ejeta, G., M.M. Hassen and E.T. Mertz, 1987. In vitro digestibility and amino acid composition of pearl millet (*Pennisetum typhoides*) and other cereals. Proc Nat Acad Sci., 84: 6016–6019

El-Anany AM and F.M. Ali, 2012. Studies on hypolipidemic effects of coconut oil when blended with tiger nut oil and fed to albino rats. Grasas Y Aceites,63:303–312.

Eltayeb Van, M.M., A.B.Hassn, M.A. Sulieman and E.E. Babiker, 2007. Effect of Processing Followed by Fermentation on Antinutritional Factors Content of Pearl Millet (*Pennisetum glaucum L.)* Cultivars. Pakistan Journal of Nutrition, 6 (5): 463-467.

FAO/ WHO/UNU, 2002. Protein and amino acid requirements in human nutrition: report of a joint FAO/WHO/UNU expert consultation. World Health Organ Tech Rep Ser2007;935:1–265.

Ferris, D.A., R.A. Flores, C.W. Shanklin, 1995. Proximate analysis of food service wastes. Appl Eng Agric.,11:567–572

Fisher, R.A., 1970. Statistical Method for Research Workers, Eds. Oliver and Boyed, Edinburgh, pp: 140-142.

Food and Nutrition Board, 1989. National Research Council.Recommended dietary allowances, rev, 18th ed. Washington, DC: National Academy Press.

Gahlawat, P. and S. Sehgal, 1994.Shelf life of weaning foods developed from locally available food stuffs. Food Human Nutr., 45 (4): 349-355.

Grewal A. and S. Jood, 2006. Effect of processing treatments on nutritional and antinutritional contents of green gram. J. Food Biochem., 30:535-46

Gross, R., F. Koch, I. Malaga, A. F. de Miranda, H. Schoeneberger and L. .T Rugo, 1989. Chemical composition and protein quality of some local Andean food sources. Food Chemistry, 34(1): 25-34.

Gustavo V.B., A.J. Fontana, J.S. Shelly, T.P. Labuza, 2008. Water Activity in Foods: Fundamentals and Applications. Ames, IA, USA: Blackwell Publishing Professional, 155–172.

Hariharan, M., S. Naga, V. Noord, 1993. Systematic approach to the development of plasma amino acid analyses by high performance liquid chromatography with ultraviolet detection with pre column derivatization using phenyl isothiocyanate. J Chromatogr, 621:15-22.

Haskell, M.J., K.M. Jamil, F.Hassan, J.M. Peerson, M.I. Hossain, G.J. Fuchs and K.H. Brown, 2004. Daily consumption of Indian spinach (*Basella alba*) or sweet potatoes has a positive effect on total-body vitamin A stores in Bangladeshi men. American J. Clin. Nutr.,80: 705-714

Hellstrom, A., A.M. Hermansson, A. Karlsson, B. Liungquist, D. Melander and U. Svanberg, 1981. "Dietary bulk as a limiting factor for nutrient intake in pre-school children. II. Consistency as related to Dietary Bulk – A model study". J. Trop. Pediatr., 27(3) 127-135.

Huffman, S.L., H.L. Uman and M.A. Martin, 1994. First feedings: optimal feeding of infants and toddlers. Nutr. Res., 14:127–159.

Ihekoronye, A.I. and P.O. Ngoddy, 1985. Integrated Food Science and Technology for the Tropic. Macmillan publishers limited, London and Basinstoke. pp. 253-257.

Ijarotimi, O.S., 2008. Protein and hematological evaluations ofinfant formulated from cooking banana fruits (*Musaspp, ABB genome*) and fermented Bambara groundnut (*Vigna subterranean L. Verdc*) seeds. Nutr. Res. Pract., 2:165–170.

Iwe, M. O., 2002. Hand Book of Sensory Methods and Analysis Rojoint Communication Publishers Ltd. Enugu. pp.1-50

Jenny, R., Y. Grijalva, P. Lopez-Jaramillo and B.M. Nair, 2002. The nutritional quality of an infant food from quinoa and its effect on the plasma level of insulin-like growth factor-1 (IGF-1) in undernourished children International Journal of Food Sciences and Nutrition , 53: 143–154

Karuna, D., G. Noel and K. Dilip, 1996. Production and use of raw potato flour in Mauritian traditional food . Food and nutrition bulletin, 17: 2, United Nation University

King, J., D.O. Nnanyelugo, H. Ene-Obong and P.O. Ngoddy, 1985. Household consumption profile of cowpea (*Vigna unguiculata*) among low-income families in Nigeria. Ecol. Food Nutr., 16:209-221

Kinsella, I.E., 1976. Functional properties of proteins in foods. A survey critical reviews in Food Sci. Commercialition, 7: 219-232

Klopfenstein, C.F. and R.C. Hoseney, 1995. Nutritional properties of sorghum and the millets., Sorghum and millets: chemistry and technology. In, American Association of Cereal Chemistry. D. A. V. Dendy (Ed.) St. Paul., 125–168.

Koziol, M.J., 1992. Chemical Composition and Nutritional Evaluation of Quinoa (*Chenopodium quinoa* Willd.), Journal of Food Composition and Analysis. 5: 35-68

Krishnan, R., U. Dharmaraj and N.G. Malleshi, 2012. Influence of decortication, popping and malting on bio accessibility of calcium, iron and zinc in finger millet. LWT-Food Sci. Technol., 48: 169-74.

Kulkarni, K.D., D.N. Kulkarni and U.M. Ingle, 1991. Sorghum malt-based weaning formulations preparation, functional properties, and nutritive value. Food and Nutr. Bulletin, 13 (4): 322-327

Lanzmann, P.D.,2001.Alpha-linolenic acid and cardiovascular disease. J. Nutr. Health Aging, 5:179–183.

Lilian, E.A.J., 2009. Quinoa (*Chenopodium quinoa* Willd.): Composition, Chemistry, Nutritional, and Functional Properties, Advances in Food and Nutrition Research, 58:1-31

Low, J.W., M. Arimond, N. Osman, B. Cunguara, F. Zano and D.A. Tschirley, 2007. food-based approach introducing orangefleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique.J Nutr., 137:1320–1327

Mahgoub, S.E.O. and S.A. Elhag, 1998. Effect of milling, soaking, malting, heat-treatment and fermentation on phytate level of flour Sudanese sorghum cultivars. Food Chem., 61:77

Malik, M., U. Singh, S. Dahiya, 2002. Nutrient composition of pearl millet as influenced by genotypes and cooking methods. J .Food Sci .and Technol., 39(5): 463-468.

Malleshi, N.G., M.A. Daodu and A. Chandrasekher, 1989. Development of weaning food formulations based on malting and roller drying of sorghum and cowpea. Int. J. Food Sci. Technol., 24(5):511-519.

Nnam, N.M., 2000. Evaluation of effect of sprouting on the viscosity, proximate composition and mineral content of Hungary rice, acha (*Digiteria exillis*) flours. Nigerian Food Journal, 18, 57–62

Nzeribe, H.C. and C.C. Nwasike, 1995. The brewing potential of acha (*Digiteria exlils*) malt compared with pearl millet (*Pennisetum glaucum*) malt and sorghum (Sorghum bicolar) malts. J. Inst. Brewing, 101: 345-350.

Olu-Owolabi, B.I., S.O. Fakayode, K.O. Adebowale and P.C. Onianwa, 2007. Proximate, elemental composition and their estimated daily intake in infant formulae from developed and developing countries: a comparative analysis. J. Food Agric. Environ., 5(2):40–44.

Opara, B. J., N. Uchechukwu, R.M. Omodamiro, N. Paul, 2012. Production and sensory evaluation of food blends from maize-plantain-soybean as infant complementary food. J. Stored Products Posthar. Res., 3(6): 75-79.

Osundahunsi, O.F., T.N. Fagbemi, E. Kesselman, and E. Shimoni, 2003. Comparison of the physicochemical properties and pasting characteristics of flour and starch from red and white sweet potato cultivars. J. Agric. Food Chem., 51: 2232-2236

Ou, J., H. Tu, B. Shan, A. Luk, R.A. DeBose-Boyd, Y. Bashmakov, J.L .Goldstein and M.S. Brown, 2001. Unsaturated fatty acids inhibit transcription of the sterol regulatory element binding protein-1c (SREBP-1c) gene by antagonizing ligand-dependent activatio of the LXR. Proc Natl. Acad .Sci .USA., 98:6027–6032.

Pasko, P., H. Barton, P. Zagrodzki, A. Izewska, M. Krosniak, M. Gawlik, 2010. Effect of diet supplemented with quinoa seeds on oxidative status in plasma and selected tissues of high fructose-fed rats. Plant Foods Hum. Nutr., 65 (2): 146-151

Plaami, S. P., 1997. Content of dietary fibre in foods and its physiological effects. Food Review Int., 13(1): 29-76.

Repo-Carrasco, R., C. Espinoza and S.E. Jacobsen, 2003. Nutritional value and use of the Andean crops quinoa (*Chenopodium quinoa*) and Kañiwa (*Chenopodium pallidicaule*). Food Reviews International, 19(1-2): 179-189.

Repo-Carrasco-Valencia, R., J.M. Hellstro¨m Pihlava and P.H. Mattila, , 2010. Flavonoids and other phenolic compounds in Andean indigenous grains: Quinoa (*Chenopodium quinoa*), Kan˜iwa (*Chenopodium pallidicaule*) and Kiwicha (*Amaranthus caudatus*). Food Chem., 120: 128–133.

Ruales, J. and B. Nair, 1993. Effect of processing on the physico-chemical characteristics of the quinoa flour(*Chenopodium quinoa,* Willd). Starch/Starke., 45(1):13–19.

Sajilata, G., S.S. Rekha, and R.K. Pushpa, 2002. Weaning foods: A review of the Indian experience, Food and Nutrition Bulletin, 23(2):208-226

Sani, I., 2015. Analysis and preliminary phytochemical screening of oil extract from two varieties of Cyperuses culentus tubers. Int. Research J. Pharm. Biosci. , 2 (1): 18- 24.

Sanny, S.L., E.L. Chan, E.L. Ferguson, B. Karl, F. Umi, B. Himothy, S.G. Rosalind, 2007. The concentrations of iron, calcium, zinc and phytate in cereals and legumes habitually consumed by infants living in East Lombok, Indonesia. J. Food Compos. Anal.,20:609–17.

Serna-Saldivar, S.O., C.M. McDonovgh, and L.W. Rooney, 1991. The Millets Ch. 6 in: Handbook of Cereal Science and Technology. K. Lorenz and K.J. Kulp, eds. Marcel Dekker, New York. Pp 271-300

Shahidi, F. and A. Chandrasekara, 2013. Millets grain phenolics and their role in disease risk reduction and health promotion: A review. Journal of Functional Foods., 5: 570-581

Spehar, C.R. and P.I. de M. Souza, 1993. Adapting the quinoa (*Chenopodium quinoa* Willd) to cultivation in the brazilian highlands: preliminary results. Pesquisa Agropecuária Brasileirapecuária Brasileira, 28(5): 635-639

Stajić, S., D. Živković, M. Perunović, S. Šobajić and D. Vranić, 2011.Cholesterol content and atherogenicity of fermented sausages made of pork meat from various breeds. Procedia Food Sci., 1:568–575

Stubbs, C.D. and A.D. Smith, 1984. The modification of mammalian membrane polyunsaturated fatty acid composition in relation to membrane fluidity and function. Biochim Biophys Acta.,27:89–137.

Suma, P.F. and U. Asna, 2014. Influence of germination on bioaccessible iron and calcium in pearl millet (*Pennisetum typhoideum*). J. Food Sci. Technol., 51(5): 976-981.

Suma, P.F. and U. Asna, 2017. Impact of Household Processing Methods on the Nutritional Characteristics of Pearl Millet (*Pennisetum typhoideum*): A Review. MOJ Food process Technol 4(1):1-5.

Takashi, S. and P.A. Seib, 1988. Paste and gel properties of prime corn and wheat starches with and without native lipids. J. of Cereal Chem., 65: 474-480.

Tawfik, L.M., 1999. The preparation of some highly-nutritive,low-cost baby food formulas. Suez Canal Univ. Med. J., 1:241–251.

USDAU.S. Department. Of Agriculture, Agricultural Researc Service, 2005. USDA national nutrient database for standard reference, Release 18. Nutrient Data Laboratory.

Valencia-Chamorro, S.A., 2003. Quinoa. In: Encyclopedia of Food Science and Nutrition. Caballero B Academic Press, Amsterdam, 8: 4895–4902.

Valencia-Chamorro, S.A., C. Wrigley, H. Corke, and C.E. Walker, 2004. Quinoa. In: Encyclopedia of grain science, Elsevier L., (pp. 1-8).

Van Hal, M.V., 2000. Quality of sweet potato flour during processing and storage. Food Rev. Int.,16:1–37

Vega-Gálvez, A., M. Miranda, J. Vergara, E. Uribe, L. Puente, and E.A. Martínez, 2010. Nutrition facts and functional potential of quinoa (*Chenopodium quinoa* willd.), an ancient Andean grain, a review. Journal of the Science of Food and Agriculture, 90(15): 2541-2547.

Walker, S.P. and K.A. Gavin, A. Ashworth and J.M. Gardner, 2002.Complementary Foods in Jamaica:Viscosity energy density and feeding practices. Public Health Nutrition, 5 (2): 295-302

Waller, W.M. and D.B. Duncan, 1969. A Bayes rule for the symmetric multiple comparison problem J. Am. Statistical Assoc., 64: 1484-1499.

Wang, J.C. and J.E. Kinsella, 1976. Functional properties of novel proteins; alfalfa leaf protein. J. Food Sci., 41: 286-289.

WHO, 1998. Complementary feeding of young children in developing countries. A review of current scientific knowledge, Geneva, pp: 133-134.