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Ngozi M Nnam * , Catherine A Orisa , Ijioma Okorie

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Article

Functional and Sensory Properties of Infant Complementary Foods Formulated from Millets, Orange-Flesh Sweet Potatoes, Carrots, Periwinkle and Oyster

Ngozi Mercy Nnam [1,*], Catherine Achese Orisa [2] and Ijioma Okorie [3]

[1] Department of Nutrition and Dietetics, University of Nigeria Nsukka, Enugu State, Nigeria.
[2] Department of Home Science and Management, Rivers State University, Nkpolu Oroworukwo, Port Harcourt Rivers State, Nigeria
[3] Michael Okpara University of Agriculture Umudike Abia State, Nigeria.
* Correspondence: +2348037573076; ngnnam@yahoo.com

Abstract: The study evaluated the functional and sensory properties of infant complementary foods formulated from millets, orange-flesh sweet potatoes, carrots, periwinkle and oyster. Experimental/cross-sectional design was used. Millet, orange-flesh sweet potato (OFSP), carrots, periwinkle and oyster were purchased, processed into flour using standard methods. The complementary food was formulated on protein basis for infants 6–12 months. The formulated foods were millet/OFSP flours (70:30), millet/OFSP/carrot/periwinkle (49:29:7:15), and millet/OFSP/carrot/oyster (65:20:5:10). Functional properties were carried out using standard methods. Sixty nursing mothers attending Orogbum Health Centre were systematically sampled for the sensory evaluation. ANOVA was used for the study. The result showed packed density (0.77 g/mL) was significantly higher ($p < 0.05$) in food formulated from millets/OFSP than in millet/OFSP/carrot/oyster (0.68 g/mL). Loosed density was lowest (0.40 g/mL) in millet/OFSP/carrot/oyster. Carr index from ranged from 42.23 in millet/OFSP/carrot/oyster to 44.41 in millet/OFSP. Wettability was highest (45.03) in millet/OFSP/carrot/periwinkle compared to wettability value (26.53) for millet/OFSP. Solubility ranged from 18.36 to 46.62, with the highest (46.62) in millet/OFSP/carrot/periwinkle. The peak viscosity of the infant complementary food samples ranged from 64.53 rapid visco analyzer units (RVU) to 89.33 RVU. The infant complementary food formulated from millet/OFSP had significantly higher ($p < 0.05$) acceptability score (6.35).

Keywords: infant complementary food; functional properties; sensory properties

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Introduction

Intake of cereal-based food products such as millets and root-tuber (orange-fleshed sweet potato) are common in developing countries. These food crops are mainly used as staple foods, with high deficiency in protein (Anosike et al., 2020). Foods of high biological value are vital and must be provided in order to complement breast milk and thus, meet the nutrient requirement of an infant.

Complementary food is a liquid, semi-solid and/or solid food given to an infant other than breast milk between the ages of 6 and 24 months of life (Akinola et al., 2014; Anosike et al., 2020). Complementary feeding is a process of complementing infants' diet from 6 months, as breastmilk would no longer be adequate to provide the nutritional needs of the infant (Pearce & Langley-Evans, 2013). Complementary foods are formulated to contain high energy density including adequate protein composition, required vitamins and minerals to meet the nutrient needs of the infant. Poor dietary quality and feeding practices or both are the major challenges during complementary feeding (Mitchodigni et al., 2018). The major problems affecting most children, particularly infants are lack of adequate protein and micronutrients intake in terms of quality and quantity from complementary foods (Sharma & Kumar, 2017). Furthermore, traditional complementary foods in most cases are made from mono cereal gruel such as millet, guinea corn, maize, sorghum, which are deficient in essential amino acids, particularly lysine. A combination of cereal, tuber, vegetables and sea foods in

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the formulation of complementary food may help to make up for the deficiency in essential amino acids and micronutrients in mono-cereal traditional complementary foods. However, functional properties are given less attention while much attention is given to the quality and quantity of nutrient the food would supply (Anosike et al., 2020). Appropriate consistency of complementary food is guided by the functional property of a food, and for easy swallowing of a food by an infant, the food's consistency must be adequate. According to World Health Organization (WHO) (2003) as reported by Anosike et al. (2020) a good complementary diet should contain high nutrient (both macro- and micronutrient) density, low bulk density (BD), viscosity, appropriate texture and consistency that allows for ease of consumption.

In most low-income countries, newborn complementary diets are cereal and starch-based. Starch is the primary source of energy, yet, when cooked, starch forms gel, resulting in a thick and bulky diet with low energy density but a liquid consistency that is simple to ingest. The amount required to fulfill the child's energy needs frequently exceeds the maximum volume that the infant can consume. Because of the low calorie and nutrient density, substantial quantities are generally provided to satisfy the infant's demand without taking into account the infant's restricted stomach capacity or the number of meals administered each day (Anosike et al., 2020).

The general acceptability of complementary foods by infants is influenced by its functional properties such as water absorption capacity, solubility, bulk density, wettability, and pasting properties. The functional properties are paramount to ensure appropriateness and usability of the complementary food. The study evaluated the functional and sensory properties of infant complementary foods formulated from millets, orange-fleshed sweet potato, carrot, periwinkle and oyster.

Materials and Methods

Experimental/research and development design was adopted for the study in order to evaluate the functional and sensory properties of infant complementary foods formulated from millets, orange-fleshed sweet potatoes, carrots, periwinkle and oysters.

Orange-flesh sweet potatoes (*Ipomoea batats* L), millets (*Eleusine coracana*) and carrots (*Daurus carota* L) were purchased from Nsukka market in Enugu State, Nigeria, while periwinkle (*Tympanatonus* fuscatus) and oysters (*Crassostrea madrasenis*) were purchased from Creek Road Market in Port Harcourt Local Government Area of Rivers State, Nigeria. Identification of the plant food materials were done at the Department of Plant Science and Biotechnology, while that of animal food materials were carried at the Department of Animal Science, all in University of Nigeria Nsukka.

Sample Preparation

The method described by Oguizu et al. (2019) was adopted in the study to process 70 kg of orange-fleshed sweet potatoes into flour. They were peeled, washed and sliced with a kitchen knife. The slices were immediately immersed in a water bath of 1% sodium metabisulfite for 10 minutes to prevent enzymatic browning. The orange-fleshed sweet potatoes was drained and oven dried at 55^0C in a conventional air oven (Gallen Kamp Co. Ltd London England) for 8 hrs. The dried product was then milled in a laboratory mill (Thomas Willey Mill Model ED-5) into fine powder and sieved into flour using 0.4mm sieve aperture. The flour sample was packed in a zip lock bag and stored in a refrigerator at -4^0C for further study.

One hundred kilograms (100 kg) of millets was processed by fermentation into flour by adopting the method described by Iombor et al. (2009). The grains were sorted, cleaned and soaked in clean tap water in a covered container. The soaked grains were allowed to ferment at room temperature (25^0C) for 24 h. The water was drained after fermentation and the grains were rinsed with 500 mL of water and oven dried at 60^0C for 3 h. The oven dried grains were milled in a laboratory hammer mill (Thomas Willey Mill Model ED-5) and sieved into fine flour (30 mm sieve aperture). The flour sample was packed in zip lock bags and stored in a refrigerator at -4^0C for further study.

Thirty kilograms (30 kg) of carrots was washed, scrapped to remove the epidermis and some sub-epidermal tissues and then blanched at 80°C for 6 minutes, sliced and dried at 30^oC for 3 hours

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in a conventional air oven. The dried carrots were then milled into flour using a Kenwood milling machine model AT941A. The resulting flour was stored in air tight zip lock bags at room temperature of 25^{0}C protected from light and humidity for further use.

The method described by Ufot et al. (2018) was used to process 30 kg of periwinkle into flour. The periwinkle was thoroughly washed with tap water to remove mud and other debris. It was then put in a stainless pot of boiling water and allowed to cook for 5 minutes at 100^{0}C, then dried using an aluminum sieve and allowed to cool to ambient temperature of about 25^{0}C. The edible portion was manually removed from the shell with the aid of a sterilized stainless pin/needle. The shells were discarded and the periwinkle washed in potable tap water, drained, dried at 55^{0}C overnight in a conventional air oven. The dried periwinkles were milled to flour using a Kenwood milling machine model AT941A. The resulting flour was stored in air tight zip lock bags at room temperature (25^{0}C) protected from light and humidity for further use.

Thirty kilograms (30 kg) of oysters were thoroughly washed with clean tap water to remove mud and other debris. They were then put in a stainless pot of boiling water and allowed to cook for 5 minutes at 100^{0}C, then drained using an aluminum sieve and allowed to cool to ambient temperature (25^{0}C) The edible portion was manually removed from the shell with the aid of a cleaned kitchen knife. The shells were discarded and the edible portion of the oysters were washed in clean tap water, drained and dried in a conventional air oven at 55^{0}C overnight. The dried oysters were milled to flour using a Kenwood milling machine model AT941A. the resulting flour was stored in air tight zip lock bags at room temperature of 25^{0}C protected from light and humidity for further use.

Formulation of Composite Flour from Millets, Orang-Flesh Sweet Potatoes, Carrots, Periwinkle and Oyster Meat

The protein content of each food was determined by micro Kjeldahl procedure (AOAC, 2012). This was used for the formulation of the composite flours. Combination of millet with carrot, orange-fleshed sweet potato, oyster and periwinkle was done using the recommended guideline for the formulation of complementary food for infants 6–12 months (Codex Alimentarius Commission, 2012). It states that on dry weight basis, composite flour for complementary food should contain a minimum of 4 kcal/g carbohydrate, while the energy from protein should not be less than 6% of the total energy from the product and typically should not exceed 15% and dietary fibre content should be reduced to a level not exceeding 5 g per 100g (Codex Alimentarius Commission, 2012). The composites were formulated from the processed flours on protein basis, using the following ratios:

Millet/orange-flesh sweet potatoes 70:30 (Diet 1)
Millet/orange-flesh sweet potatoes/carrot/oyster meat flour 65:20:5:10 (Diet 2)
Millet/orange-flesh sweet potatoes/carrot/periwinkle meat flour 49:29:7:15 (Diet 3)

Table 1. Quantity of protein provided by each food item and the quantity of food item required to supply the required protein (15 g).

Sample	Ratio	Millet (g)	Carrot (g)	OFSP (g)	Oyster (g)	Periwinkle (g)	Total (g)
Millet/OFSP	70:30	10.5(150.1)	-	4.5(144.3)	-	-	15(294.4)
MOCOM	65:20:5:10	9.75(139.3)	0.75(83.3)	3.00(96.2)	1.50(2.3)	-	15(321.1)

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MOCPM	49:29:7:15	7.35(105.0)	1.05(116.7)	4.35(139.4)	-	2.25(3.2)	15(364.3)

OFSP = orange-flesh sweet potato; MOCOM = millet, orange-flesh sweet potatoes, carrots and oyster; MOCPM = millet, orange-flesh sweet potato, carrot and periwinkle meat.

The composition was based on 15 g protein bases per day requirement for children 6-24 months (Codex Alimentarius Commission, 2012). Table 1 shows the quantity of protein provided by each food item and the quantity of food item that will supply the stated quantity of protein. Diet 1 (millet/orange-fleshed sweet potatoes) is 70:30 which means that 70% of millet flour provided 10.50% protein and 30% orange-fleshed sweet potatoes provided 4.50% protein. The quantity of millet that supplied 10.50% of protein required 150.1 g of processed millet flour while the protein requirement of infants (6-12 months) is 15 g per day (Codex Alimentarius Commission, 2012). The quantity of food item that will supply the quantity of the protein is in the bracket. Diet 1 has 294.4g quantity of the composite to supply 15g/day, diet 2 has 321.1 g while diet 3 has 364.3 g quantity of the composite flour to supply 15 g/day.

Determination of functional properties

Determination of water absorption capacity

The water absorption capacity was carried out according to the method described by Omeire et al. (2014). An empty centrifuge tube was washed, dried and weighed. Thereafter 0.5 g of the sample was transferred into the tube and re-weighed. About 5 ml of distilled water was transferred into the tube containing the sample and allowed to stand for 30 minutes. The tube was centrifuged at 3500 rpm for 30 min and the supernatant was measured in a measuring cylinder and recorded. The tube containing the sediment was also weighed.

Calculations

Sample weight= Weight of tube - Weight of empty tube

Water absorbed (g) = (Weight of tube + sediment) - (Weight of tube + sample)

Water absorbed (g/g) = $\frac{Water\ absorbed\ (g)}{Sample\ weight}$

Water absorbed (ml/g) =$\frac{Water\ absorbed\ in\ ml}{Sample\ weight}$

Determination of Solubility

Solubility was determined according to the method given by Omeire, et al. (2014). The sample (0.5 g) was weighed into a conical flask and 10ml of distilled water added. The conical flask was covered with a foil paper and heated in a water bath shaker for 1 hr using 40 oscillations per min. The conical flask was removed and cooled. Thereafter the sample was transferred into a centrifuge tube and centrifuged at 3500 rev/sec for 30sec. Previously washed, dried and cooled moisture can was weighed and recorded. The weight of the swelling volume was also recorded and the supernatant was poured into the moisture can and dried at 105^{o}C in an oven for 1 h. The dresidue and the centrifuge tube were weighed while the moisture-can was cooled in the desiccator and weighed.

Calculations

Solubility or solute= (Weight of can + solute) - Weight of empty can

% Solubility= $\frac{Weight\ of\ solute\ or\ solubility}{Sample\ weight} \times \frac{100}{1}$

Determination of Bulk Density

This was determined using the method described by Omeire, et al. (2014). Two point five grams (2.5 g) of the sample was put in a 10 ml graduated cylinder and the bottom of the cylinder was tapped repeatedly onto a firm pad on a laboratory bench until a constant volume was observed. The packed

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volume was recorded. The bulk density was calculated as the ratio of the sample weight to the volume occupied by the sample after tapping.

Bulk density (g/ml) = weight of sample (g) / volume of sample (ml)

Determination of Wettability

The wettability index is defined as the time (in seconds) required for wetting all particles of a specified amount of powder (sink under the water surface) when placed on the surface of the water at a specified temperature. It was determined by the method described Nguyen, et al. (2015). One hundred milliliter (100 ml) of distilled water at 25°C was poured into a 400 ml beaker (diameter 70mm). A glass funnel (height 100 mm, lower diameter 40 mm, upper diameter 90 mm) was placed and maintained on the upper edge of the beaker. A test tube was placed within the funnel to block the lower opening of the funnel. Three grams (3 g) powder was placed around the test tube; while the timer was started, the tube was simultaneously elevated. Finally, the time was recorded when the powder is completely wet (visually assessed that all powder particles have diffused into the water). The measurement was performed at least twice for each sample and until the relative difference between the two results do not exceed 20%

Pasting Properties

Pasting properties of the samples was read using the Rapid Visco Analyzer (RVA Model 3c, Newport Scientific PTY Ltd, Sydney) as described by Pomeranz (1985). Briefly, 5.00g of sample was weighed into a weighing vessel; 25 ml of distilled water was dispersed into a new test canister. Samples were transferred onto the water surface of the canister after which the paddle was placed into the canister. The blade was vigorously joggled up and down through the sample ten times or more until no flour lumps remained either on the water surface or the paddle. The paddle was properly centred into the canister and the measurement cycle initiated. Peak viscosity (RVA), peak time (min), peak temperature (°C), trough (RVU), pasting temperature (°C) and final viscosity (RVU), breakdown and setback viscosities (RVU) were read on the instrument. The RVA pasting curve was automatically plotted. The viscosities, temperature and time was expressed in Centipoise (cP), degree Celsius (°C) and minutes respectively.

Sensory Evaluation of the Gruels

Selection of panelists: The population for the sensory evaluation comprised of nursing mothers attending the Orogbum Health Centre, Port Harcourt Trans Amadi Industrial Layout, Rivers State. As at the time of the study, there were seventy-five nursing mothers attending the hospital. A systematic random sampling was used to select 60 nursing mothers for the sensory evaluation. The researcher went to the hospital two weeks before the study to meet with the hospital management. The essence of the visit was to obtain ethical approval and to get acquainted with the mothers who were involved in evaluating the sensory properties of the formulated diets prepared by the researcher in the hospital.

Gruel (thin porridge) preparation: A standard recipe as described by Nnam & Baiyeri (2008) with some modification was used for the preparation of the gruels. They were prepared from each of the three composite flour samples. one hundred and fifty grams of each flour sample was reconstituted with 500 mL of clean water. The slurry was heated slowly and stirred constantly for 10 minutes to obtain smooth gruel.

Testing section

The research assistants helped to organize the nursing mothers for sensory evaluation. Four mothers each were seated in a row. The gruels were coded to avoid bias. Each sample was served in a plate with a testing spoon. Each nursing mother was provided with a glass of water for rinsing her mouth to avoid carryover effect. A nine-point hedonic scale was used with 1 and 9 representing dislike extremely and like extremely, respectively (Iwe, 2010). The research assistants helped the nursing mothers to fill their own form. The panelists were divided into six groups of ten each and the study was carried out in six days.

Statistical Analysis

Data obtained from the functional properties and sensory evaluation were subjected to statistical analysis using IBM-SPSS version 26. Analysis of variance (ANOVA) was used to analyze the various data, while multiple range test was used for means separation.

Results

Table 2 shows the functional properties of the infant complementary food samples. The result showed that the packed density was significantly ($p < 0.05$) higher (0.77 g/mL) in infant complementary food sample formulated from millets/orange-flesh sweet potato (OFSP), compared to infant complementary food sample formulated from millet/OFSP/carrot/oyster (0.68 g/mL). Loosed density was significantly ($p < 0.05$) lower (0.40 g/mL) in millet/OFSP/carrot/oyster. The result showed that water absorption capacity of the formulated infant foods was significantly ($p < 0.05$) higher (1.91 g/g) in millet/OFSP/carrot/periwinkle compared to millet/OFSP/carrot/oyster (1.70 g/g). Carr index of the samples ranged from 41.23 in millet/OFSP/carrot/oyster to 44.41 in millet/OFSP. Gelation temperature was significantly ($p < 0.05$) higher (84.90^{o}C) in millet/OFSP/carrot/oyster compared to millet/OFSP/carrot/periwinkle (77.75^{o}C) and millet/OFSP (77.90^{o}C). Wettability was significantly ($p < 0.05$) higher (45.03) in millet/OFSP/carrot/periwinkle compared to wettability values (39.74 and 26.53, respectively) for millet/OFSP/carrot/oyster and millet/OFSP infant complementary food. Solubility ranged from 28.84 to 46.62. The solubility was significantly ($p < 0.05$) higher (46.62) in millet/OFSP/carrot/periwinkle infant complementary foods.

Table 3 shows the pasting properties of the infant complementary food samples. The peak viscosity of the infant complementary food samples ranged from 64.53 rapid visco analyzer units (RVU) to 89.33 RVU, with significant ($p < 0.05$) value (89.33 RVU) of peak viscosity observed in formulated millet/OFSP infant complementary food compared to 73.62 RVU in millet/OFSP/carrot/periwinkle and 64.53 RVU in millet/OFSP/carrot/oyster. Also, there was significant difference ($p < 0.05$) in trough viscosity between millet/OFSP (48.02 RVU), millet/OFSP/carrot/oyster (33.07 RVU) and millet/OFSP/carrot/periwinkle, while breakdown viscosity (41.31 RVU) was significantly ($p < 0.05$) highest in the formulated millet/OFSP infant complementary food. Final viscosity was significantly ($p < 0.05$) highest (112.00 RVU) in the formulated millet/OFSP/Carrot/Periwinkle infant complementary food. Setback viscosity was significantly ($p < 0.05$) highest (70.84 RVU) in infant complementary food formulated from millet/OFSP/Carrot/Periwinkle. The peak time was significantly ($p < 0.05$) highest (5.00 minutes) in infant complementary food formulated from millet/OFSP, also the pasting temperature of millet/OFSP/Carrot/Periwinkle (82.57^{0}C) was comparable to the pasting temperature of millet/OFSP (82.68^{0}C) infant complementary food.

Table 4 shows the sensory evaluation of the formulated infant complementary foods. Among the formulated infant complementary foods, the mean value for colour was significantly ($p < 0.05$) lowest (4.85) in millet/OFSP/carrot/periwinkle, while in terms of aroma, formulated millet/OFSP was significantly ($p < 0.05$) preferred (6.35). Formulated complementary food from millet/OFSP/carrot/oyster was tastier (6.40) and thicker (6.50) compared to the other formulated complementary foods (5.25–5.65). The infant complementary food formulated from millet/OFSP was significantly ($p < 0.05$) more acceptable (6.35) compared to complementary foods formulated from millet/OFSP/carrot/oyster (5.87) and millet/OFSP/carrot/periwinkle (5.38).

Discussion

Samples incorporated with periwinkle and oyster meat flour had the lowest bulk density (0.68 – 0.69 g/mL), thereby result in thinning of the gruel. Bulk density of the flours is very important in determining packaging requirement and material handling (Orisa & Udofia, 2020). Low bulk density observed in the study contributed to the acceptability and lower dietary bulk. Also at the industrial scale, it contributes to ease of packaging and transportation, thereby increasing the profitability of the products. Furthermore, the formulated complementary foods are desirable for infants, due to ease of swallow, devoid of choking and/or suffocation. Therefore, low bulk density seen in millet/OFSP/carrot/oyster and millet/OFSP/carrot/periwinkle implied that the product can be prepared with small amount of water with high energy and nutrient density. There were variations in the water absorption capacity of the formulated complementary foods as a result of different concentration of protein and the degree of interaction with water, and conformational characteristics. The water absorption capacity is a required attribute during food formulation especially in infant food formulation. It is determined by the ability of protein in flours to physically bind water (Ikpeme-Emmanuel et al., 2010). The presence of periwinkle which is rich in protein explains why formulated millet/OFSP/carrot/periwinkle had the highest water absorption capacity. This is in line with previous study by Orisa & Udofia (2020) that periwinkle meat flour with a high protein quality absorb more water than OFSP, carrot and millet flours. Carr index is a frequently used attribute of flow ability in powdered products. The Carr index is less in any free-flowing product because of very minimal difference between bulk density and tapped density while in a poor flowing powder where there is greater particle interaction, the Carr index would be larger. Formulated millet/OFSP/carrot/oyster had low Carr index which indicated a superior flow-ability of the product and it is in agreement with the study by Jadhav et al. (2017) on the Carr index of formulated products. Also millet/OFSP/carrot/periwinkle had high wettability values contributing ease of dispersing the complementary food product in water, and this is also a marketability factor in promoting the product at scale. Orisa & Udofia (2020) noted that wettability is a function of ease of dispersing flour samples in water. The higher wettability values (39.74 and 45.03) for the complementary foods incorporated with periwinkle and oyster indicates that the blends would wet faster than complementary food made up of millet and orang-flesh sweet potato (26.53).

The low peak viscosity (64.53 and 73.62, respectively) observed in the infant complementary food formulated from millet/OFSP/carrot/oyster and millet/OFSP/carrot/periwinkle is an indication of low gel strength and elasticity. High peak viscosity reveals high starch content. The high peak viscosity (89.33) seen in infant complementary food formulated from millet and OFSP indicates that the product would form a very thick paste hence suitable for products that require low gel strength and elasticity (Abioye et al., 2011; Orisa & Udofia, 2020). Peak viscosity is the ability of starches to swell freely before their physical breakdown and it indicates the strength of the paste formed during gelatinization. Therefore, the oyster and periwinkle incorporated into the products led to the low peak viscosity and/or reduced bulk density with increased nutrient density. Similar finding was also reported by Egbujie & Okoye (2019) for complementary foods formulated from sorghum, African yam bean and crayfish flours. Trough is the minimum viscosity which measures the ability of paste to withstand breakdown during cooling. High trough viscosity (48.02 RVU) observed in millet/OFSP blends implies that the food would withstand high heat treatment during processing than the formulation containing periwinkle and oyster. The breakdown viscosity is essentially a measure of the degree of paste stability or starch granules distribution during heating (Oluwalana et al., 2012). The low breakdown viscosity observed in formulated food from millet, OFSP, carrot and oyster (31.46 RVU) and from millet, OFSP, carrot and periwinkle (33.06 RVU), indicates that the products would form more stable paste during heating process than the formulated product from millet/OFSP (41.31 RVU). This is in agreement with the study by Egbujie & Okoye (2019) who reported reduced breakdown viscosity (34.61 RVU) in sorghum based complementary food incorporated with crayfish flour.

The result on peak time showed that both complementary foods incorporated with oyster and periwinkle had low peak time (4.91 minutes) and would cook faster than millet/OFSP blends with a high peak time (5.00 minutes). This is because peak time is usually regarded as an indication of the total time taken for each sample to attain its respective peak viscosity. Infant complementary food formulated from millet/OFSP and millet/OFSP/carrot/periwinkle requires higher pasting temperature than complementary food formulated from millet/OFSP/carrot/oyster (82.40^{0}C). Pasting temperature indicates the minimum temperature required to cook a given food product, which also provides information on the energy usage (Orisa & Udofia, 2020).

The colour variation is attributed to the periwinkle and oyster incorporated into the formulations, which gave the products slightly green colouration. Okoye & Ene (2018) reported a similar colour change in a complementary food formulated from malted maize, black bean, and crayfish flour. The low taste in millet/OFSP/carrot/periwinkle blends was also attributed to the unfamiliar taste of periwinkle used in the formulation. A similar finding was recorded by Onabanjo et al. (2019) for complementary foods formulated from sorghum, sesame, carrot and crayfish. Infants are likely to reject unfamiliar flavour. This calls for modification of the formulation in order to reduce the level of unfamiliar taste and thus, promote the products at a large scale for consumption. Similarly, low score for aroma was also observed in millet/OFSP/carrot/oyster (3.90) and millet/OFSP/carrot/periwinkle (5.65) and was attributed to the presence of oyster and periwinkle in the formulated products. Low general acceptability (5.87 and 5.38, respectively) in the products with oyster and periwinkle also mean that there is need to include natural colour and flavour enhancers in formulating the infant complementary foods. This will help to improve the general acceptability of the products for infant consumption.

Conclusion

The results on functional and sensory properties showed that the formulated infant complementary foods would be suitable for infant consumption. However, there is need to enhance the colour and flavour of the products that contained oyster and periwinkle flours, thereby scale up the production of these complementary foods at the industrial level.

Table 2. Functional properties of the formulated infant complementary foods.

Samples	Packed density (g/mL)	Loosed density (g/mL)	Water absorption (g/g)	Carr index	Gelation temp (^{0}C)	Wettability	Solubility
Millet/OFSP	0.77^a	0.43^a	1.64^b	44.41^a	77.90b	26.53^c	28.84^c
MOCOM	0.68^b	0.40^b	1.70^a	41.23^a	84.90^a	39.74^b	42.73^b
MOCPM	0.76^{ab}	0.43^a	1.91^a	43.10^a	77.75^b	45.03^a	46.62^a

Mean values with different superscripts in the same column are significant ($p < 0.05$). OFSP = orange-flesh sweet potato; MOCOM = millet, orange-flesh sweet potato, carrot and oyster; MOCPM = millet, orange-flesh sweet potato, carrot and periwinkle meat.

Table 3. Pasting properties of the formulated infant complementary food.

Samples	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (Minutes)	Pasting temp (^{0}C)
Millet/OFSP	89.33^a	48.02^a	41.31^a	102.02^b	53.36^b	5.00^a	82.68^a
MOCOM	64.53^c	33.07^c	31.46^b	80.42^c	48.07^c	4.97^a	82.40^a
MOCPM	73.62^b	40.56^b	33.06^b	112.00^a	70.84^a	4.91^a	82.57^a

Mean values with different superscripts in the same column are significant ($p < 0.05$). OFSP = orange-flesh sweet potato; MOCOM = millet, orange-flesh sweet potato, carrot and oyster; MOCPM = millet, orange-flesh sweet potato, carrot and periwinkle meat.

Table 4. Sensory properties of the formulated infant complementary foods.

Samples	Colour	Aroma	Taste	Thickness	Acceptability
Millet/OFSP	7.25^{a}	6.35^{a}	6.20^{a}	5.25^{b}	6.35^{a}
MOCOM	5.05^{b}	5.90^{b}	6.40^{a}	6.50^{a}	5.87^{b}
MOCPM	4.85^{c}	5.65^{b}	5.55^{b}	5.6^{5b}	5.38^{b}

Mean values with different superscripts in the same column are significant ($p < 0.05$). OFSP = orange-flesh sweet potato; MOCOM = millet, orange-flesh sweet potato, carrot and oyster; MOCPM = millet, orange-flesh sweet potato, carrot and periwinkle meat.

References

1. Anosike, F.C., Nwagu, K.E., Nwalo, N.F., Ikegwu, O.J., Onyeji, G.N., Enwere, E.N. & Nwoba, S.T. (2020). Functional and pasting properties of fortified complementary foods formulated from maize (*Zea mays*) and African yam bean (*Sphenostylis stenocarpa*) flours. *Legume Science*; 2:e62. https://doi.org/10.1002/leg3.62
2. Akinola, O. O., Opreh, O. P. and Hammed, I. A. (2014). Formulation of local ingredient-based complementary food in South-west Nigeria. *Journal of Nursing and Health Science*, 3 (6): 57-61
3. Pearce, J. and Langley-Evans, S. C. (2013). The types of food introduced during complementary feeding and risk of childhood obesity: a systematic review. *International Journal of Obesity*, 37, 477–485.
4. Mitchodigni, I.M., Amoussa Hounkpatin, W., Ntandou-Bouzitou, G., Termote, C., Bodjrenou, F.S.U., Mutanen, M. & Hounhouigan, D.J. (2018). Complementary feeding practices among children under two years old in West Africa: A review. Afr. J. Food Agric. Nutr. Dev. 18(2): 13541-13557
5. Sharma, H.K.& Kumar, N. (2017). Utilization of Carrot Pomace. Food Processing by-products and their utilization. First Edition. John and Wiley Sons Ltd. https://doi.org/10.1002/9781118432921.ch10
6. WHO (2003). *Feeding and Nutrition of Infants and Young Children: Guidelines for the WHO European region with emphasis on the former Soviet Union.* (87).WHO Regional Publications, European Series, Pp1-296.
7. Oguizu, A.D., Utah-Iheanyichukwu, C. and Raymond, J.C. (2019). Nutrient evaluation of infant food produced from orange fleshed sweet potatoes (*Ipomoea batatas*) and soybean blends (Glycine max). *International Journal of Food Science and Nutrition*, 4(3): 107-113.
8. Iombor, T.T., Umoh, E.J. and Olakumi, E. (2009). Proximate composition and organoleptic properties of complementary food formulated from millet (*Pennisetum psychostachynum*), soybeans (*Glycine max*) and crayfish (*Euastacus* spp). *Pakistan Journal of Nutrition*, 8(10): 1676-1679.
9. Ufot, E. I., Idorenyin G. E. and Barthlomew, N. E. (2018). Comparative Study on the Chemical Composition and Amino Acid Profile of Periwinkle and Rock Snail Meat Powders. *International Journal of Food Science and Biotechnology*. 3(2): 54-59.
10. AOAC (2012). Association for Official Analytical Chemist. *Official Methods for Analysis*, 19th Ed. Washington DC.
11. Omeire, G.C., Umeji, O.F. and Obasi, N.E. (2014). Acceptability of Noodles Produced from Blends of Wheat, Acha and Soybean Composite Flours. *Nigerian Food Journal*, 32(1): 31-37.
12. Nguyen, D.Q., Mounir, S. and Allaf, K. (2015). Functional Properties of Water Holding Capacity, Oil Holding Capacity, Wettability, and Sedimentation of Swell-Dried Soybean Powder. *Scholars Journal of Engineering and Technology*, 3(4B):402-412
13. Pomeranz, Y. (1985). Carbohydrates: Starch composition occurrence and uses In: Functional properties of food components. Academic Press Inc., Orlando, pp. 25-28.
14. Nnam, N. and Baiyeri, G. (2008). Evaluation of the Nutrient and Sensory Properties of Multimixes and Porridges Made from Maize, Soybean, and Plantain for Use as Complementary Food. *Ecology of Food and Nutrition.* 47. 64-76.
15. Iwe, M.O. (2010). *Handbook of Sensory Methods and Analysis*. Rojoint Communication Services Ltd. Enugu. pp. 75-78.
16. Orisa, C.A. and Udofia, S.U. (2020). Functional and Pasting Properties of Composite Flours from *Triticum durum*, *Digitaria exilis*, *Vigna unguiculata* and *Moringa oleifera* Powder. *Asian Food Science Journal*, 19(2): 40-49.

17. Ikpeme-Emmanuel, C.A., Osuchukwu, N.C. and Osheile L. (2010). Functional and sensory properties of wheat (Asetium triticuim) and taro flour (Colocasia esulanta) composite bread," *African Journal of Food Science*, 4:248-253.
18. Jadhav, H.T., Ozoh, C., Marripudi, S.T., Cao, X. & Rosentrater, K.A. (2017). Studies on Ground Corn Flowability as Affected by Particle Size and Moisture Content. An ASABE Meeting Presentation DOI: https://doi.org/10.13031/aim.201701175 Paper Number: 1701175
19. Abioye, V.F., Ade-Omowaye, B.I.O., Babarinde, G.O. and Adesigbin, M.K. (2011). Chemical, physicochemical and sensory properties of plantain flour. *African Journal of Food Science*, 5:176-180.
20. Egbujie, A.E. and Okoye, J.I. (2019). Quality characteristics of complementary foods formulated from sorghum, African yam bean and crayfish flours. *Science World Journal*, 14(2): 16-22.
21. Oluwalana, I.B., Malomo, S.A. and Ogbodogbo, E.O. (2012). Quality assessment of flour and bread from sweet potato-wheat composite flour blends. *International Journal of Chemistry and Biological Sciences*, 6(1):65-76.
22. Okoye, J.I. and Ene, G.I. (2018). Evaluation of nutritional and organoleptic properties of maize-based complementary foods supplemented with black bean and crayfish flours. *Global Advanced Research Journal of Food Science and Technology*, 6(1): 1-9.
23. Onabanjo, O.O., Akinyemi, C.O. and Agbon, C.A. (2009). Characteristics of complementary foods produced from sorghum, sesame, carrot and crayfish. *Journal of Natural Sciences, Engineering and Technology*, 8(1): 71-83.