Food Science and Quality Management www.iiste.org
ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)
Vol.15, 2013

Dietary Fortification of Sorghum-Ogi using Crayfish (*Paranephrops planifrons*) as Supplements in Infancy

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Abstract

Malnutrition in neonates is a concern in developing countries where there is deficiency in nourishing foods for young ones. The utilization of fresh crayfish (*Paranephrops planifrons)* in enhancing the nutrient value of commonly used sorghum grain weaning food for infancy was investigated. The study was carried out using a 10 – 50 wt% mixture of sorghum grain and crayfish in three categories of soaked sorghum grains with unroasted crayfish (Case A); de-hulled roasted sorghum grains with roasted crayfish (Case B) and de-hulled, un-roasted sorghum grain with un-roasted crayfish (Case C). The proximate analysis, functional and pasting properties in addition to taste panel evaluation of the batch composition were determined. The result indicated beneficial fat and protein contents of the blend with increase addition of crayfish with Case B and Case C preferred. The overall acceptability at 5% confidence level of organoleptic evaluation identified Case B with over 70% acceptance value, while the amylograph pasting analysis indicated that crayfish blend improved the stability of sorghum-ogi, hence it is beneficial as weaning food for infancy.

Keywords: Crayfish, sorghum-ogi, amylograph pasting, infant nutrition, organoleptic test.

1. Introduction

The development and growth of infants is a function of appropriate diet taken especially during the first twenty four months of their life. The World Health Organization (WHO) has suggested that children should be breast fed for at least first six months after which supplementary foods can be introduced to bridge the energy, iron and vitamin A gaps that may arise in breastfed infants during the first six months (WHO 2001; WHO 2002**).** Only one-third of breastfed babies between the ages of 6 and 23 months received age appropriate dietary diversity and proper feeding frequency (WHO 2011). Breast milk contains several immune components with specific modulating potentials, which are known to have a clear role in immune mediated disease resistance later in life. From research findings, most diseases that neonates are predisposed to after weaning are mostly as a result of lack of appropriate nutrients that assist in the fortification of their immune system (Pierro and Eaton 2008; Monte & Giugliani 2004; Hay *et al*. 2004;Young & Drewett 2000). Research studies indicated that early introduction of solid food at < 3 months of age is always associated with lower family socioeconomic position which results in inability to meet infant nutritional demands. This malnutrition increases susceptibility to infectious diseases and affects child mortality from diseases such as diarrhea, whooping cough, and acute respiratory infection (Lin *et al.* 2013; Uwaegbute & Nnanyelugo 1987). Good nutrition at this age is crucial, as unavailability of certain key nutrients for a given age could result in physical and mental retardation that may be irreversible. This also reduces the capacity of the host to resist the consequences of such infection, thereby making death inevitable for some.

The World Health Organization associates 35 percent of diseases in children under 5 with malnutrition (WHO/UNICEF 1988). In Nigeria, the neonatal mortality estimated about a decade ago reported 71 of every 1000 children (Grant 2001). The energy and protein intake of infants and children of the low-income group has been discovered to be one of the factors responsible for one-third of the infants suffered varying degrees of malnutrition (2%) and were wasted (7%) and stunted (32%) and with 28% prevalence for underweight (UNICEF 2012; Shafique *et al*. 2007; Akinrele & Omotola 1986). It is therefore clear that during the period of weaning, these infant are very vulnerable to malnutrition, and one of the major factors is traced to inadequate food intake, hence they cannot resist these infections (Musaiger *et al*. 2011; Onofiok & Nnanyelugo 2005). The frequent occurrence of such infections leads to malnutrition because of increased energy and nutrient requirements coupled with poor absorptive capacity. This in turn affects the nutritional status of the child and further lowers resistance to infection.

In Nigeria, the usual first weaning food is called *Ogi, or dogit* and is made from maize, millet, or guinea corn, which most mothers introduce at three to six months of age. Majority of families from low-income groups seldom feed their neonates with meat, eggs, or fish, because of socio-economic factors. Instead, they feed their infants with the usual first weaning food called pap or ogi, which is made from maize (*Zea mays*), millet (*Pennisetum americanum*), or guinea corn (*Sorghum*) (Ajanaku *et al*. 2012; Ijarotimi & Ogunsemore 2006). However, pap contains only 310 kcal/100g of Energy, 1.8% protein and less than 1% fat, as compared with 9% protein and 4% fat obtained from original corn. This is because considerable losses occur during the fermentation process of 2-3 days, which is followed by wet-milling and wet-sieving. Therefore, as cereals that are generally low in protein and are limiting in some essential amino acids, supplementation of cereals with protein sources becomes inevitable to increase protein content of weaning food. Hence, this study was conducted to evaluate the nutritional value of complementary feeding using crayfish (*Paranephrops planifrons*) as supplements to enhance the popular weaning food (ogi) for babies in Nigeria.

2. Sample Preparation

Sorghum grain, obtained at Nigerian Brewery Plc, Lagos and Fresh crayfish from Institute of oceanography, Lagos were mixed in ratio 90:10, 80:20, 70:30, 60:40, and 50:50 weight %. The sorghum grain (1000 g) was processed in three categories of soaked, milled, sieved and dried; the second category was de-hulled and roasted at 65^{o}C and milled to 100 mesh; the third category was de-hulled, unroasted and passed through 100 mesh BS size. The sorghum grain was prepared by soaking in 5 litre of water for 72 hrs, milled using Hobart mixer at medium speed for 7 min and the slurry passed through 100 mesh. The suspension obtained was left to stand for 1 hr for the ogi to settle. The supernatant was decanted and the ogi collected was sieved and oven dried at 70^{o}C for 2 days and stored in an airtight container. The crayfish was also processed in two categories of roasted and un-roasted. Fresh weighed crayfish (200 g) was slightly roasted at 75^{o}C to edible state without allowing it to burn. The grains were grounded in Hobart mixer, afterwards sieved with 100 mesh BS and kept in an airtight container.

2.1 Preparation of the sorghum-ogi blends

100 weight % of sorghum-ogi (dry basis) was mixed with 10 - 50 g of crayfish (dry basis) as shown in **Table 1** while 0 g of crayfish was used as control based on the three batch formulations: Case A – soaked sorghum flour with unroasted crayfish; Case B - de-hulled and roasted sorghum with roasted crayfish and Case C – de-hulled and un-roasted sorghum with un-roasted crayfish. The recipe was mixed in a Hobart mixer for 5 min after adding 20 ml of distilled water. Hot, boiling distilled water was added to each blend and thoroughly mixed to obtain ogi-slurry, cooled to room temperature and analysed.

2.2 Experimental

Moisture content, ash content, crude fat and total nitrogen by the standard micro-kjeldahl method were determined using the method of AOAC (1984); (1975). The percent nitrogen was converted to crude protein using 6.25 factor while the carbohydrate content was determined by difference. The pH of the sample blends were measured on a unican model pH meter which had been previously standardized with buffer solutions of pH 4 and 9. Titratable acidity was determined by method of Banigo & Muller (1972). Diastatic activity was determined using Blish and Sandstedt method as described by Kent-Jones & Amos (1967). Sugar analysis was determined using the AOAC (1975) method. Vitamin C (ascorbic acid) was determined by the oxidation - reduction method based on the reduction of indophenol dye by an acid extract of the ascorbic acid. The bulk density of the samples was determined by method of Narayana & Narasinga-Rao (1984) while Water Absorption Capacity was calculated by method of Solsulski (1962). Pasting viscosity was determined on a brabender Amylograph by method described by Adeyemi (1983) and Banigo *et al.* (1974). Assessment by a ten-man panelist comprising of tasters who were familiar with the product was carried out on the sorghum-ogi-crayfish porridge batch samples. The assessment was based on a 7-point Hedonic scale for taste, appearance, texture, colour and acceptability. The data obtained were in triplicates and are subjected to analysis of variance.

3.0 Result and Discussion

The result of the chemical composition of the recipe materials used in the study is shown in **Table 2**. The result typified any blend of sorghum with crayfish will result in a balanced meal with nutitional value that satisfy the needs for energy and protein. Whenever there is deficiency of protein and energy, there will be negative manifestations, ranging from weight loss to growth retardation which is associated with deficiencies of vitamins and minerals (e.g. vitamin A, iron and calcium) which, finally may result in clinical manifestations like marasmus and kwashiorkor. The chemical composition obtained from the two recipe connotes that resulting diet from the two blend will be rich in Carbonhydrate, Protein, Iron, Calcium and Vitamin A. The increase in protein value will be majorly contributed by the addition of crayfish (73.8%) while carbonhydrate (65%) and vitamin A (290 IU) will be from sorghum grain. Iron and calcium enrichment will be from contribution of the two recipes.

3.1 Effect of crayfish blending on the proximate analysis of ogi recipe

The moisture content of food sample is an indication of the safety and microbial stability of food, hence samples are always preferred dried below critical moisture content. Knowledge of the moisture content is frequently necessary in order to predict the behavior of foods during processing since this affect factors like mixing, drying, and even packaging. In F**igure 1a**, the moisture content of the three blends against the batch compositions are shown. It was observed that Case A has the highest value of moisture as compared with other cases. This is definitely expected because the composition is made up of soaked and then dried sorghum mixed with unroasted crayfish which has added to the total moisture of the food material. Roasting of the food materials has helped in achieving minimal moisture content as observed in Cases B and C, which has also added value to the texture, taste, appearance and stability of the foods with Case C preffered over Case B. This result is comparable with the results of the Nikzadeh & Sedaghat (2008) on the effect of both roasting temperature and storage period having significant effect on moisture content, textural changes and sensory attributes of food samples.

The ash content as well as the protein content of all the blends increases with increase in the content of crayfish with Case C having highest value in batch F (50/50 wt%). Protein is seen as the building block of life that is necessary for repairs and maintenance of the body system. It becomes necessary for neonates to have enough content of such for development and growth once weaning begins. A closer observation on **Figure 1c** revealed that Batch F has highest value in all cases observed in this work, with implication that this batch will be suitable to supply the required essential amino acid for nutritional based food for neonates with high protein content.

The fat requirement for neonates is essential for the development of brain especially for children under two years of age, which is much different from the nutritional recommendation for adults. **Figure 1d** revealed the fat content of the blend samples with batch composition. It was observed that the introduction of crayfish in the blend increased the fat content of all the batches when compared with the control, with Case A and B having good value in Batches B and F. In order to meet requirement for fat content, two blends in relative composition of 10% and 50% of crayfish respectively, depending on processing, is required. When the protein content of these same batches was compared, an observation to avoid obesity became pertinent, with awareness that too much fat content may result to plumpness. In order to sustain a sense of balance between fatness and protein content, Batch F cases B or C is preferred because of high protein content and average fat content thereby making the supplement a balanced diet for neonates.

Figure 1e shows the CHO content of the blend against the batch composition. As it was expected, the CHO content reduced with increase in crayfish content with Case A having the lowest value in Batch F composition.

3.2 Taste panel assessment of crayfish-ogi blends

The taste panel assessment of the blends is shown in **Table 4** for quality attribute for all the samples. The results were in triplicates and were treated with analysis of variance method with obtained values plotted and analysed. The results analysed for taste, texture and sweetness indicated Control and Cases B blends to be significantly different from the other samples at 5% confidence level with the control only significantly difference from other samples for texture. This typified that Case B is mostly preferred after the control sample. Furthermore, Case A blend is preferred for colour and flavor and is also significantly different from the other blends apart from the control blend. For overall acceptability, Case B has value above 70% while other cases are less than 70% acceptance.

3.3 *Amylograph pasting viscosity of crayfish-Ogi Blends*

Crayfish is robust for consumption by virtue of the nourishment in terms of total fat, cholesterol, sodium as well as protein that it contains. In addition, there is also a healthy supply of vitamin D and A, calcium, potassium, copper and zinc in crayfish with no adverse effect on the physiology of the body system (Ravichandran *et al.* (2009); Ojewola & Annah (2006); McDonald *et al.* (2000). According to the LSU Agricultural Centre, crayfish meat is more easily digested than other types of meat due to its short muscle fibers. Crayfish included in the diet may offer some of the health benefits ascribed to seafood in general, including protection against cancer, asthma and heart disease (Heli & Brandy (2013). The amylograph pasting viscosity result of the samples is presented in **Table 4**. The peak viscosity (Vp) ranged between 320 for control and 340 B.U for 50%wt substitution with temperature at peak viscosity in the range of 91 – 96 ^{o}C; indicating that addition of crayfish did not significantly alter the swelling property of ogi. Stability value of the starch (Vp – Vr) decreased from 100 B.U to 50 B.U at

50%wt level of crayfish addition. This is an indication that crayfish tends to improve the stability of sorghum ogi. Though, an increase of 10 B.U. was observed at the 10%wt addition, nut this later decreased as the crayfish level increased. Set back values (ve – vp) ranged between 470 and 530 B.U. while the gelatinization index (ve – vr) was in 590 and 610 B.U range. Therefore, it could be inferred that the pasting characteristics of sorghum crayfish ogi blends are not significantly different from the normal sorghum ogi other factors affecting pasting viscosity being equal.

5. Conclusion

In the light of the current finding of fortification of the popular sorghum-ogi weaning food in Nigeria with crayfish; it is concluded that these crayfishes are the good source of protein as well as essential minerals that is required as immediate nourishment when babies reach weaning stage. It is well understood from the current study that crayfish has its own nutritional value parameters which helps in the enhancing the dietetic sense of sorghum to meet its usage as weaning food. The nutritional parameters could be beneficial as constituent of a staple diet even for adults feeding formulation, thereby enhancing crayfish application in food industry.

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Table 1: Proportion of components in each batch composition (wt%)

Sample	A	B	C	D	E	F
Crayfish (g)	0	10	20	30	40	50
Sorghum (g)	100	90	80	70	60	50

Table 2: Chemical composition of Compounding Materials

	Sorghum (De-hulled)	Crayfish (Un-roasted)
Moisture, %	11.3	19.04
Protein, %	12.9	73.81
Fat, %	3.7	0.92
Fiber, %	1.2	0.22
Ash, %	1.7	0.96
CHO, %	65.3	0.86
Calcium, mg	62	21
Iron, mg	331	45
Vitamin C, mg	2.0	0.38
Vitamin A, IU	290	18

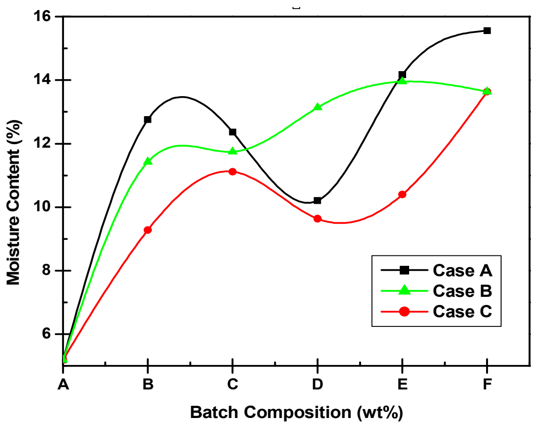
Table 3. The pH, diastatic activity, bulk density and water absorption capacity of crayfish-ogi Blends

Sample	pH	Diastatic Activity (mg maltose/100g)	Bulk density (g/ml)	Water Absorption capacity (ml)
A	4.48 ± 0.01	24.4 ± 2.12	0.838 ± 0.003	72.00 ± 2.61
B	5.22 ± 0.01	29.9 ± 3.11	0.732 ± 0.052	66.13 ± 4.26
C	5.26 ± 0.02	36.5 ± 2.22	0.712 ± 0.120	59.15 ± 3.52
D	5.62 ± 0.01	52.8 ± 2.59	0.545 ± 0.026	56.14 ± 3.29
E	5.98 ± 0.02	59.3 ± 2.48	0.447 ± 0.008	39.17 ± 2.32
F	6.11 ± 0.5	64.7 ± 3.58	0.349 ± 0.005	59.13 ± 3.68

Table 4. Amylograph Pasting Characteristics of Crayfish-Ogi Blends

Sample	Tp (mins)	Mg (mins)	Tvp (^{0}C)	Vp (B.U)	Mn (min)	Vi (B.U)	Vr (B.U)	Ve (B.U)	Mn-Mg (B.U)	Vp-Vr (B.U)	Ve-Vp (B.U)	Ve-Vr (B.U)
A	78	37	91	320	45	270	200	790	8	100	470	590
B	81	36	92	330	41	285	210	820	5	120	490	610
C	81	34	93	325	38	310	220	810	4	105	485	590
D	85	34	95	340	36	325	240	835	2	100	495	595
E	86	36	95	310	37	340	250	855	1	60	545	605
F	89	36	96	320	37	348	270	850	1	50	530	580

Tp = Pasting Temperature; Mg = Gelatinazation time; Tvp = Temperature at peak viscosity; Vp = Peak viscosity during heading; Mn = Time to reach peak viscosity; Vi = viscosity at 95^{0}C; Vr = viscosity after 30min holding at 95^{0}C; Ve = Viscosity on cooling to 50^{0}C; Mn – Mg = Ease of cooling; Vp – Vr = Stability of the starch; Ve – Vp = Set back value; Ve – Vr = Galetinization index; B.U = Bradender unit.



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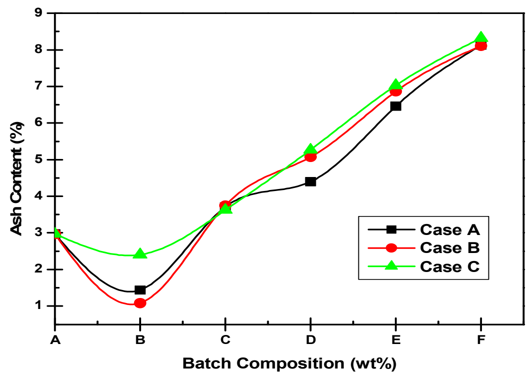

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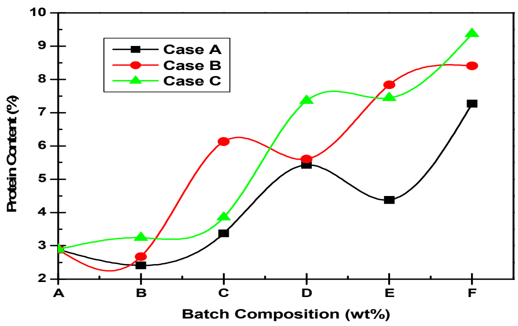

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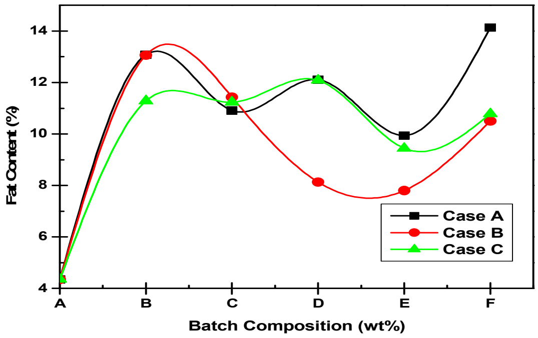

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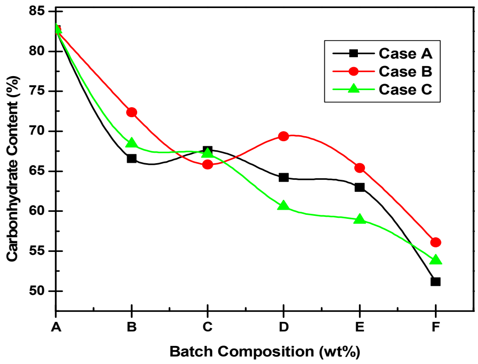

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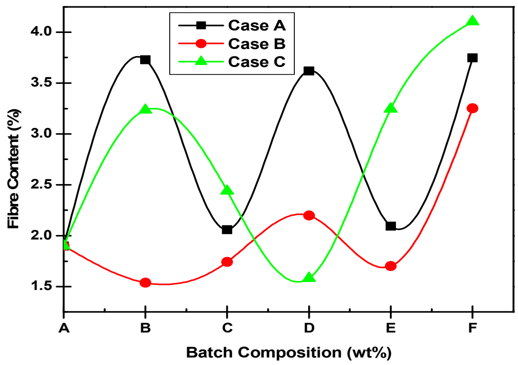

(f)

Figure 1: Variation of proximate parameters with batch composition in cases considered (a) Moisture (b) Ash (c) Protein (d) Fat (e) Carbonhydrate and (f) Fibre contents.

All the values presented are in triplicate and values are significantly different at $p<0.05$.

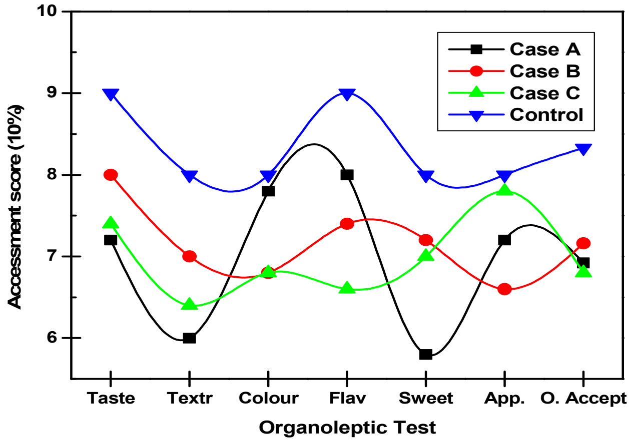

Figure 2: Variation of organoleptic test of batch composition with panel accessment score