PHYSICO-CHEMICAL AND NUTRITIONAL EVALUATION OF CO-PROCESSED FERMENTED YELLOW MAIZE OGI (AN INFANT DIET) AND CARROT BLENDS

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Abstract
Maize truly "sustains life" to most African countries as Ogi-a fermented maize meal is a popular complementary/weaning diet for infants and as well a breakfast diet for adults in most African countries, Nigeria inclusive. Yet, ogi made from maize alone does not contain adequate nutrients to meet the high nutrient demand of the neonates. The purpose of this study was to determine the effect of co-fermentation on the functional, nutritional and health benefit of fermented yellow maize and carrot blends. Three different groups of fermented maize/carrot (ogi) flour blends were produced. These include; co-fermented carrot/ogi, co-milled carrot/ogi and whole maize ogi flour as control. For co-fermented and co-milled samples, maize and carrot were blended in ratio 90:10 and 80:20 respectively. The flour yields ranged between 61.3 and 70.8%. Increase in percentage of carrot inclusion reduced yield of ogi flour. Co-milled products had higher yield than co-fermented samples. Crude protein content of the flour ranged between 8.9 and 10.3%. Significant different existed in the crude protein content of the flours at $p \leq 0.05$. Crude protein decreased while carbohydrate increased with increasing percentage of carrot. Vitamin C content of the flour ranged between 7.92 and 9.90 mg/100g and total carotenoids ranged from 4.42 to 7.27 mg/100g with significant different ($p \leq 0.05$). Vitamin C and total carotenoids increased with increasing percentage of carrot. The swelling power of the flour increased with increase in temperature. The swelling power of co-milled samples increased better at increasing temperature than the co-fermented samples. This study revealed that co-processing carrot with yellow maize to get a fortified Ogi is viable and the product is nutritionally cum health wise beneficial.

Keywords: Yellow maize, *ogi,* infant diet, Co-processing, Fermentation, Vitamin C, Total Carotenoids, physico-chemical properties

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1.INTRODUCTION

Childhood malnutrition is very common in developing countries (Kim, 2000; FAO, 2004). This is because infants at this stage of development require higher energy and proteins in their diet so as to meet increasing demand for metabolism. The nutritional status of children less than five years of age is of particular concern, since the early years of life represent the period for optimal growth and development (Prechulek *et al*., 1999). In Nigeria, cereal-based traditional infant foods do not contain enough nutrients, micronutrients and energy density to meet infant's daily requirements (Oyarekua, 2009). Malnutrition contributes directly or indirectly to more than six millions of ten million annual child deaths (WHO, 2012). Also, UNICEF (1998) reported that over 226 million children below five years old are stunted, sixty-seven million are wasted and 183 million weights less than their expected weight.

Vitamin A deficiency (VAD) has been tagged as the leading cause of preventable blindness in children and increases the risk of disease and death from severe infections. VAD also causes night blindness and may increase the risk of maternal mortality in pregnant women (WHO, 2012). Children need vitamin A for physical growth, eyes sight and for immunity against infection and disease. Vitamin a deficiency can be reduced and health of vulnerable groups can be improved by consumption of carrot and it products due to it richness in carotene (Mridula, 2011).

The American India word for corn is Maize (*Zea may*), which literarily means "that which sustains life". It is the third most important cereal grain in the world, supplying nutrients for human and animals and serving as a basic raw material for food and agro-allied industries and more recently in the production of fuel (FAO, 1992). Maize constitutes an important source of carbohydrates, protein, vitamin B, vitamin E and phytochemicals, including lignans, phenolic acid, and carotenoids (in yellow maize). It has been reported to possess antioxidant properties (Gliszczynska-Swiglo, 2006) and so they are able to protect the body against free radical induced degenerated diseases. Maize is prepared and consumed in several ways; it may be sun dried, cooked, fermented (ogi), roasted, pounded or crushed depending on locality or ethnic group (Ayatse *et al*, 1983). In Nigeria, Ogi- a fermented maize meal is a popular complementary/weaning diet for infants and as well as a breakfast diet for adults. Carrot (*Daucus carota* L.), a nutritious root vegetables is high in β- carotene, precursor of vitamin A and other valuable nutrients. According to George (2011), all varieties of carrots contain valuable amounts of antioxidant nutrients including traditional antioxidants such as vitamin C, as well as phytonutrient antioxidants like beta-carotene. Fresh carrot on an average contains (g/100g) 86 moisture, 10.6 carbohydrates, 0.9 protein, 1.2 crude fiber, 0.2 fat, 1.1 total minerals, 48 Kcal, 1890 µg b-carotene, 0.08 calcium, 0.53 phosphorous and 0.001 iron (Gopalan *et al.,* 2007).

Studies have shown that the effects of processing and method of preparation of maize may increase or decrease it's nutritive and health-promoting value depending upon method by which it is processed (IITA, 2011). Many attempts had been made by researchers to fortify ogi to be able to meet the expected nutritional requirement of the neonates; Fasasi *et al*. (2007) used Nile tilapia flour to fortified fermented maize flour, Ajanakku *et al.* (2010) utilized pawpaw fruit as a constituent of sorghum ogi. Also, Oyarekua (2011) evaluated the nutritional and microbiological status of co-fermented cereals/cowpea 'Ogi and Adeola *et al*. (2012) investigated the effects of carrot pomace on the chemical and sensory attributes of ogi. Some of these researches successfully improved the protein content of ogi, but little or no studies had been carried out to improve vitamins content of ogi which account for increasing rate of vitamin deficiency diseases among infant population. Co-processing carrot with maize could improve it vitamin A and C content. This study therefore studied the effect of co-processing (co-fermentation and co-milling) on the nutritional, physico-chemical and sensory properties of carrot /ogi blends.

2. MATERIALS AND METHODS

Production of fermented carrot/ogi blends

Yellow maize was sorted to ensure wholesomeness. The sorted grains were divided into three; a batch was fermented whole using a modified method of Adesokan *et al.*(2010) for traditional preparation of ogi. The maize obtained was washed and steeped in clean boiled water in a plastic container with cover. The water was decanted after three days (96 hrs) and the maize wet milled into slurry. The slurry was sieved using muslin cloth, which separated the pomace from the filtrate. The slurry was filtered and oven dried at 50 ^{o}C for 12hrs. The dried ogi cake was fine milled to flour (Fig.1). Another batch was co-fermented with 10 and 20% carrot (Fig. 2), and the third batch was co-milled with 10 and 20% carrot (Fig. 3).

Proximate compositions

Moisture content, total ash, crude fibre and crude fat, crude protein using Kjedal apparatus and carbohydrate content were determined by difference for all the flour samples (AOAC, 2000).

Physicochemical properties

The pH was measured by making a 10% w/v suspension of the flour sample in distilled water. The suspension was mixed thoroughly in a Sorex blender. The pH was measured with a Hanna checker pH meter (Model HI 1270) after it was calibrated with buffer 4.0 and7.0. Bulk density was determined according to the method of Okezie and Bello (1988).

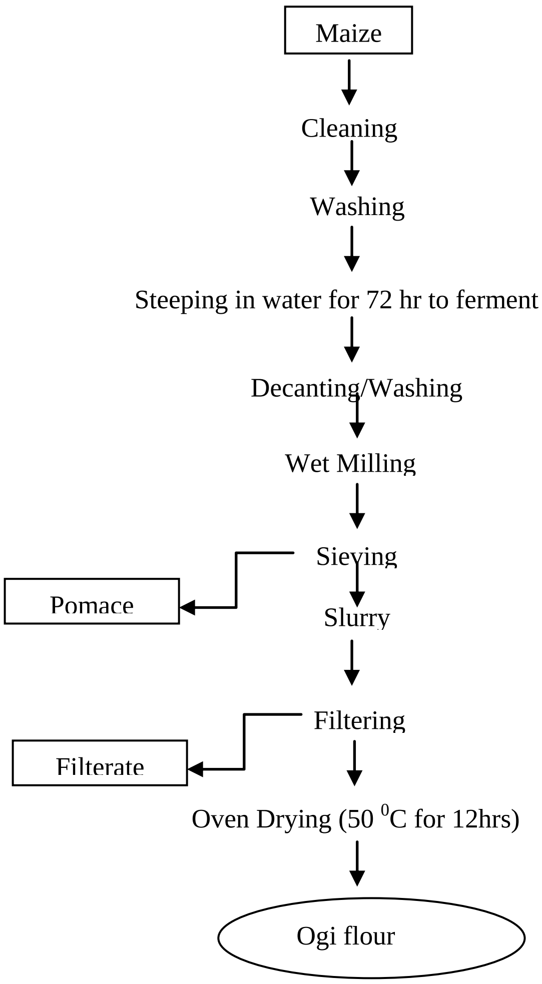

Fig.1.Production of fermented maize (*ogi)* flour

Swelling power and solubility were determined according to the method of Sathe and Salunke (1981) as modified by Gbadamosi *et al.* (2010).

Ascorbic acid and total carotenoids content

Ascorbic acid content of the blend was determined using indo phenol titration method (A.O.A.C., 2000). The total carotenoids of the samples were determined by low volume hexane extraction method as described by Fish *et al.* (2002).

Sensory evaluation

The flour (10 g) was reconstituted in 100 ml of boiling water and coded before presented to untrained twelve member panellists who are familiar with ogi to test for colour, taste, aroma, consistency, thickness and overall acceptability. Samples were evaluated for all sensory attributes on a 9- point Hedonic scale which was quantified from one for dislike extremely to nine like extremely.

Data analysis

Experimental data were generated in triplicate and the result expressed as mean ± standard deviation. Analysis of variance (ANOVA) was performed and difference in mean values were valuated using Duncan of SPSS statistics software version 17.

3. RESULTS AND DISCUSSIONS

Percentage yield of the flour samples

The percentage yield of the flour ranged between 61.3 and 70.8% (Table 1). Material balance of the samples as presented on Table 1 showed that increase in the level of carrot inclusion did not favour yield of carrot/ogi blends; the percentage yield of 10% and 20% co-fermented samples are 66.4 and 60.7% respectively. This may be due to the fact that larger percentage of carrot constituents is water. However, co-milled products had higher yield than the co-fermented blends (Table 1).

Proximate composition

The result of proximate composition of flours (Table 2) showed that the protein content of the flour ranged between 8.87 and 10.30% which is comparable to the value reported by Adegunwa *et al.* (2011) for three-day fermented yellow maize ogi. Protein content decreased with increasing carrot level; as 10.3 and 9.23% were obtained for 10% and 20% co-fermented samples respectively. Also, the crude protein content of the co-milled flour was significantly lower than the co-fermented counterparts ($p \leq 0.05$). Significant different ($p \leq 0.05$) existed in the total ash content of the flour samples except 10CF and 10CM with 3.29 and 3.30%, respectively. The fat and ash contents of the carrot/ogi blends also decreased with increasing level of carrot (Table 2).

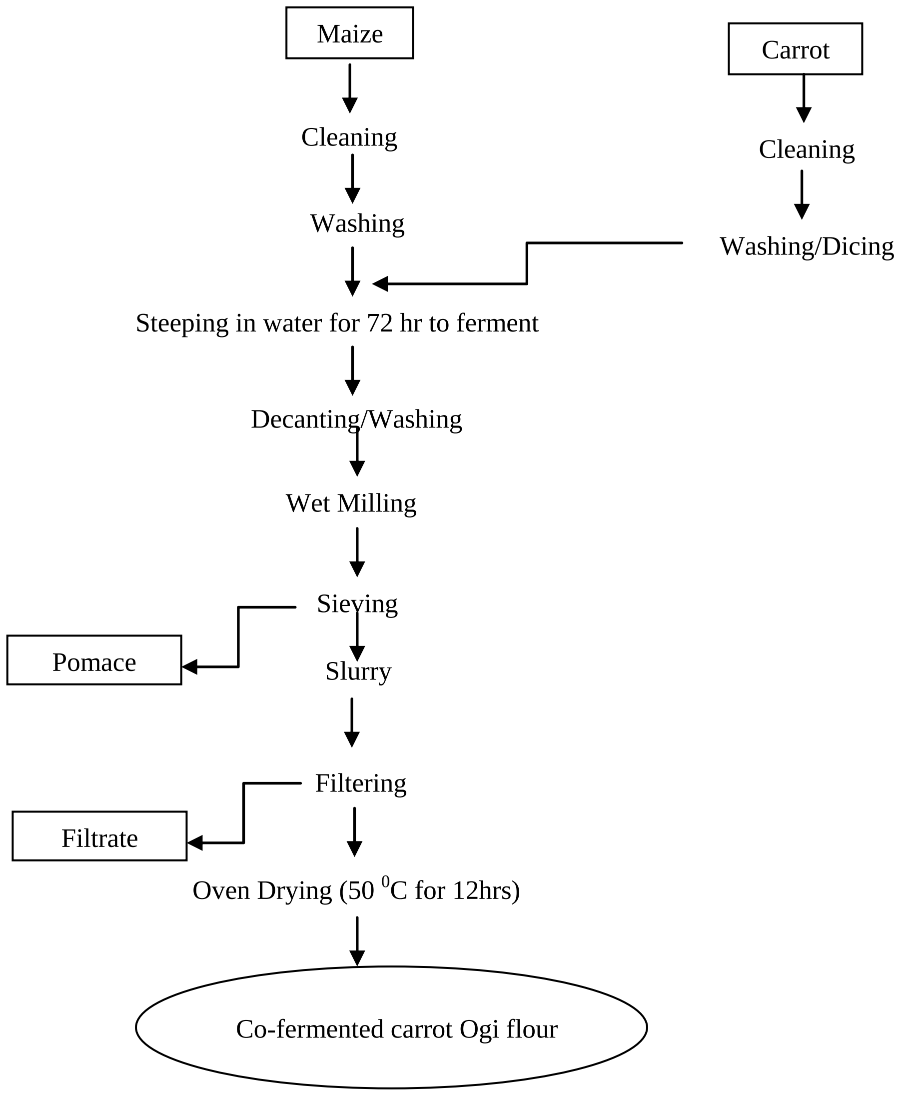

Fig. 2. Production of co-fermented carrot/ogi flour

Table 1: Material balance of various carrot/ogi blends' production

Sample Code	Description	Initial Weight (g)	Final Weight (g)	% Yield
10CF	10% carrot co-fermented with maize	500	332.0	66.4
10CM	10% carrot co-milled with maize	500	384.0	69.6
20CF	20% carrot co-fermented with maize	500	303.5	60.7
20CM	20% carrot co-milled with maize	500	306.5	61.3
C0	100% fermented maize (ogi)	1000	708.0	70.8

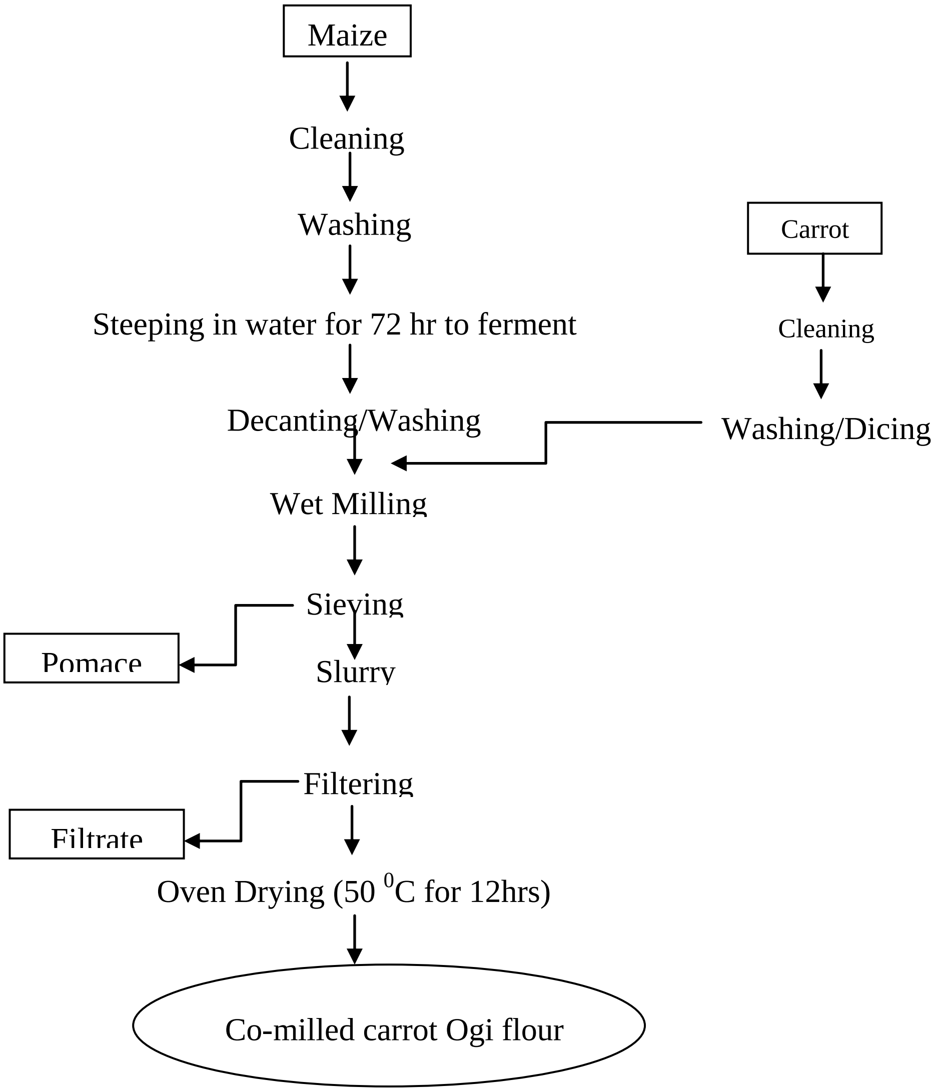

Fig. 3. Production of co-milled carrot/ogi flour

Table 2: Proximate composition of carrot /ogi blend flour (g/100 g)

Samples	C. Protein	Moisture	Fat	Ash	C. Fibre	CHO	Dry matter
10CF	10.3±0.14a	4.78±0.03a	2.86±0.03a	3.29±0.01ab	1.22±0.03a	77.63±0.01e	95.22±0.03b
10CM	9.79±0.01b	4.77±0.01a	2.86±0.09a	3.30±0.03ab	0.79±0.01b	78.49±0.07d	95.23±0.01b
20CF	9.23±0.01c	4.56±0.03b	2.68±0b	3.35±0.01a	0.77±0.02bc	79.43±0b	95.44±0.03a
20CM	8.87±0.01d	4.50±0.03b	2.53±0.04c	3.28±0.04b	0.73±0.04c	80.10±0.02a	95.50±0.03a
C0	10.20±0.03a	4.55±0.01b	2.89±0.01a	2.25±0.01c	1.21±0.01a	78.90±0.03c	95.45±0.01a

Values reported as means± standard deviation. Mean value followed by different roman letter are significantly different ($p \leq 0.05$). Key: 10CF-10% co-fermented, 10CM-10% co-milled, 20CF-20% co-fermented, 20CM-20% co-milled, and C0 - 100% ogi.

The crude fibre followed the same trend with that of protein. The fat and ash contents of the carrot/ogi blends also decreased with increasing level of carrot (Table 2).

Though the ash content does not follow a single trend, higher value of ash content was obtained for fermented samples when compared to their co-milled counterpart. This could be due to the fact that during fermentation, desirable biochemical changes could have caused significant modification to the maize through the action of microorganism which resulted to improve nutritional content (Obizoba and Atii, 1991).

Vitamin C and Total carotenoids contents of carrot/ogi blends

The vitamin C content of the flour ranged between 7.92 and 9.90 mg/100g, though without any significant different at $p \leq 0.05$. While, total carotenoids ranged from 4.42 to 7.27 mg/100g with significant different ($p \leq 0.05$). Both the vitamin C (ascorbic acid) and total carotenoids contents (Table 3) of the carrot/ogi blends increased generally with increasing percentage of carrot addition, indicating a significant contribution of carrot to the vitamin C and total carotenoids content of the blends. The same trend was observed in the vitamin C contents of earlier study in which sorghum-ogi was fortified with pawpaw (Ajanaku et *al.*, 2010) and in Baobas ogi by Adejuyitan *et al*. (2012).

Meanwhile, lower value of vitamin C content was observed in co-fermented samples when compared with their co-milled counterparts. This suggests that larger portion of the vitamin C content must have been leached into water during fermentation for fermented samples. But unlike vitamin C contents of the blends, the total carotenoids content of the co-fermented sample were higher than that of the co-milled samples; 6.96 and 5.93 mg/100g were obtained for 10% co-fermented and 10% co-milled samples, respectively. While 7.27 and 7.12 mg/100g were obtained for 20% co-fermented and 20% co-milled samples respectively (Table 3). This may be due to the fact that total carotenoids been a precursor of vitamin A - a fat soluble vitamin did not leached into the fermenting water instead fermentation has increase it availability.

pH and bulk density of carrots ogi blends

There was a general increase in the pH of the flour blends when compared with the 100% maize flour and the pH ranged from 5.71 and 6.03 with control sample and 20CM having the least pH 5.71 (Table 4). This means that all the samples are slightly acidic as it is common with all fermented foods. The pH range was higher than 4.08 and 4.36 obtained by Adesokan *et al.* (2010) for ginger/ogi blends. This may be due to the fact that substances contained in ginger which are known to contribute to the self-defence of plants against infectious organisms according to Kim *et al*. (2001) are acidic in nature.

The bulk density is a measure of ease of packing. The bulk density of carrot/ogi blends ranged between 0.93 and 0.94 g/ml (Table 4). Fasasi *et al.* (2007) reported a bulk density of 0.5-0.6 g/ml for *ogi* fortified with Tilapia fish powder and (0.41 - 0.73 g/ml) for sorghum ogi fortified with groundnut seed by Ajanaku *et al*. (2012). Addition of carrot to ogi did not significantly affect the packed bulk density of the carrot *ogi* blends except at 20% co-fermented and co-milled samples where 0.93 g/ml was obtained as against other blends including 0% carrot blend which are 0.94 g/cm3 (Table 4). Meaning that 20% carrot/ogi blends will occupy the smallest space.

Effect of temperature on solubility of carrot/ogi blends

Generally, increase in temperature favoured increase in solubility of the flour samples (Figure 4). This implies that high temperature increases thermodynamic mobility the starch granules leading to leaching, hence improved solubility; the incorporation or addition of carrot flour to fermented maize increased the solubility of carrot/ogi flour compared to 0% carrot/ogi flour. This was also observed by Fasasi *et al*. (2007) for Maize-Tilapia flour.

Table 3 : Vitamin C and Total carotene content of carrot ogi blends (mg/100 g)

Samples	Vitamin C	Total Carotene
10CF	7.92±0.01a	6.96±0.26c
10CM	8.58±0.93a	5.93±0.18d
20CF	9.24±1.87a	7.27±0.09a
20CM	9.90±0.93a	7.12±0.03b
C0	8.58±0.93a	4.42±0.03e

Values reported as means± standard deviation. Mean value followed by different roman letter are significantly different

Key: 10CF-10% co-fermented, 10CM-10% co-milled, 20CF-20% co-fermented, 20CM-20% co-milled, and C0 -100% ogi.

Table 4: Physico-chemical properties of carrot ogi blends

Samples	pH	Bulk density
10CF	5.92±0.01b	0.94±0.02a
10CM	6.03±0.02a	0.94±0.01a
20CF	5.73±0.02c	0.93±0.02a
20CM	5.71±0.02c	0.93±0.01a
C0	5.71±0.01c	0.94±0.02a

Values reported as means± standard deviation. Mean value followed by different roman letter are significantly different

Key: 10CF-10% co-fermented, 10CM-10% co-milled, 20CF-20% co-fermented, 20CM-20% co-milled, and C0 -100% ogi.

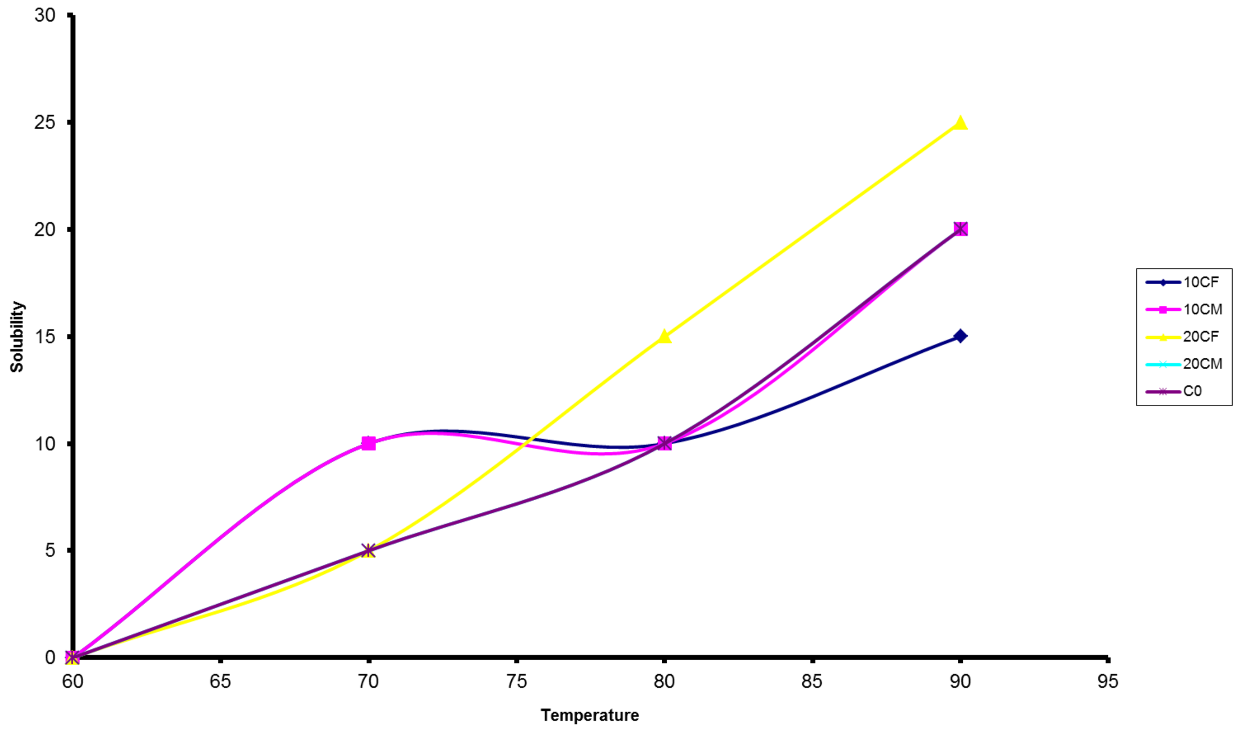

Fig. 4: Effect of Temperature on solubility of carrot/ogi blends

Table 5 : Sensory Score of reconstituted carrot /ogi blend flour

Samples	Colour	Taste	Aroma	Consistency	Overall Acceptability
10CF	3.57a	3.57a	3.43a	3.43a	3.29a
10CM	2.00c	3.00c	2.00c	2.57d	1.86c
20CF	2.57b	3.00c	3.29b	3.29b	3.00b
20CM	3.86a	3.86a	3.43a	3.29b	3.14a
C0	3.29b	3.29b	3.00b	2.71c	3.29a

Values reported as means± standard deviation. Mean value followed by different roman letter are significantly different .

Key: 10CF-10% co-fermented, 10CM-10% co-milled, 20CF-20% co-fermented, 20CM-20% co-milled, and C0 -100% ogi

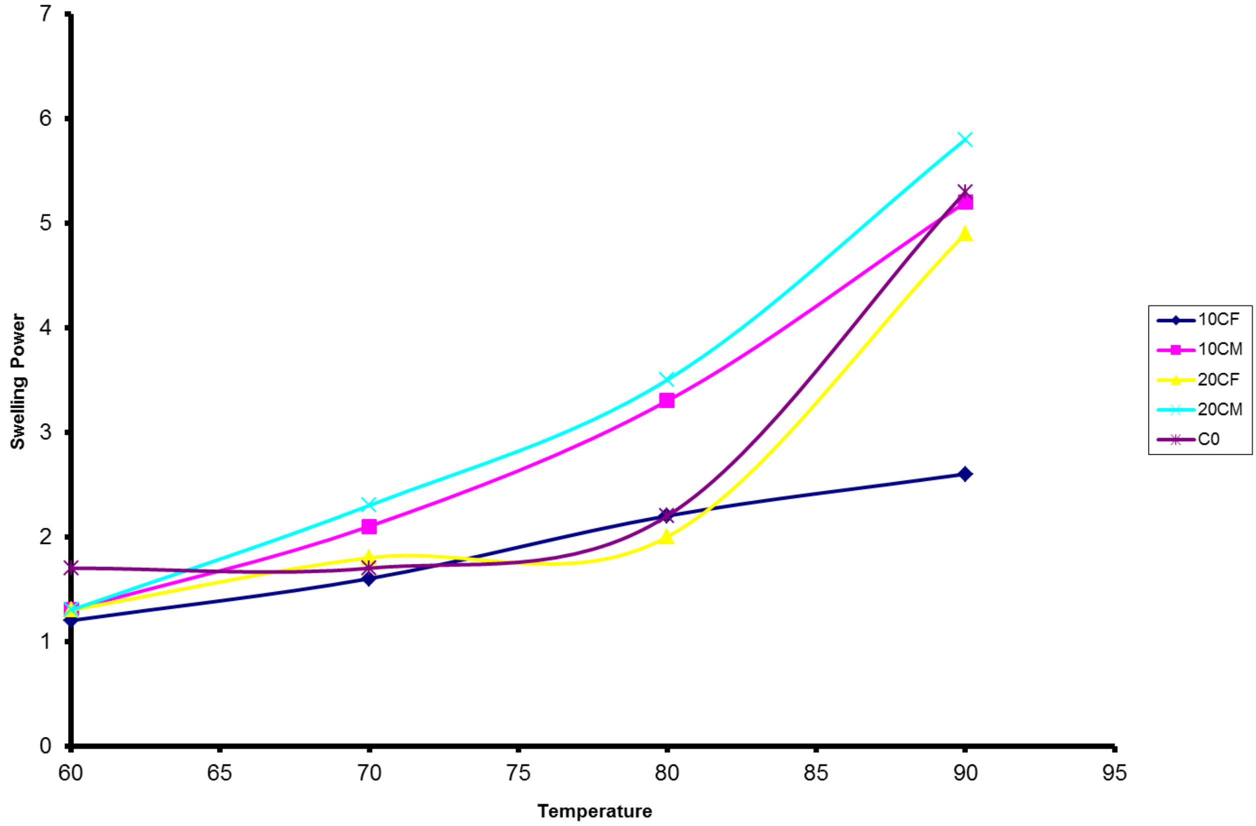

Fig. 5: Effect of Temperature on swelling power of carrot/ogi blends

All the samples were not soluble at 60 ^oC. Co-fermented and co-milling does not affect the solubility of the blends but solubility was affected by level of inclusion of carrot in the blends as 10% co-fermented and co-milled samples were more soluble at 70 ^oC than their 20% blends (Figure 4). The rates of increase in solubility of all the samples were lower between 70 ^oC and 80 ^oC than between 80 ^oC and 90 ^oC. This means that the samples will require more energy in their preparation as gelatinization may not occur until after 80 ^oC.

Effect of temperature on the swelling power of the carrot/ogi

The results of the swelling power of carrot/ogi blends are shown on Figure 5. Co-fermented samples had higher swelling power than the co-milled samples. This may imply that during fermentation, carrot might have been tightly bonded to maize as a result of uniformity better than the co-milled samples. Onitilo *et al.* (2007) suggested that the swelling power of granules reflect the extent of the association forces within the granules. Swelling power and solubility of the starches provide evidence of non-covalent bonding between molecules within the starch granules. Swelling is a factor of ratio of amylose to amylopectin, the characteristics of each fraction in terms of molecular weight - distribution degree length of branching and confirmation (Adegunwa *et al*., 2011).

Sensory Score of reconstituted carrot/ogi

The sensory score of reconstituted sample presented on Table 5. A comparison of reconstituted ogi flours fortified with carrot and the control (100% maize ogi) sample showed that significant different existed in the taste and consistency between the flour blends and the control ($p \leq 0.05$). 10CF and 20CM were significantly better than the control in terms colour, taste, aroma and consistency. There are no significant differences in the overall acceptability of 10CF, 20CM and the control sample at $p \leq 0.05$.

4. CONCLUSIONS

This study revealed that co-processing carrot with yellow maize is nutritionally and health wise beneficial. The fortification also enhanced the physico-chemical properties of the carrot/ogi gruel and improved aesthetic value of ogi. Meanwhile, co-milled sample is preferred to the co-fermented sample due to its higher micronutrient level notably vitamins C and A. However, there is need to check the microbial load of the flour sample to ensure its safety for both infant and adult consumption.

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