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≤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≤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 literally 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 (Gliszczyńska-Swigło, 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 phytounitrient 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, Ajanaku 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 sieving using muslin cloth, which separated the pomace from the filtrate. The slurry was filtered and oven dried at 50 °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).
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≤0.05). Significant different (p≤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).
Table 1: Material balance of various carrot/ogi blends’ production

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

Fig. 2. Production of co-fermented carrot/ogi flour
**Fig. 3.** Production of co-milled carrot/ogi flour

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

<table>
<thead>
<tr>
<th>Samples</th>
<th>C. Protein</th>
<th>Moisture</th>
<th>Fat</th>
<th>Ash</th>
<th>C. Fibre</th>
<th>CHO</th>
<th>Dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>10CF</td>
<td>10.3±0.14a</td>
<td>4.78±0.03a</td>
<td>2.86±0.03a</td>
<td>3.29±0.01ab</td>
<td>1.22±0.03a</td>
<td>77.63±0.01e</td>
<td>95.22±0.03b</td>
</tr>
<tr>
<td>10CM</td>
<td>9.79±0.01b</td>
<td>4.77±0.01a</td>
<td>2.86±0.09a</td>
<td>3.30±0.03ab</td>
<td>0.79±0.01b</td>
<td>78.49±0.07d</td>
<td>95.23±0.01b</td>
</tr>
<tr>
<td>20CF</td>
<td>9.23±0.01c</td>
<td>4.56±0.03b</td>
<td>2.68±0.06b</td>
<td>3.35±0.01a</td>
<td>0.77±0.02bc</td>
<td>79.43±0.06b</td>
<td>95.44±0.03a</td>
</tr>
<tr>
<td>20CM</td>
<td>8.87±0.01d</td>
<td>4.50±0.03b</td>
<td>2.53±0.04c</td>
<td>3.28±0.04b</td>
<td>0.73±0.04c</td>
<td>80.10±0.02a</td>
<td>95.50±0.03a</td>
</tr>
<tr>
<td>C0</td>
<td>10.20±0.03a</td>
<td>4.55±0.01b</td>
<td>2.89±0.01a</td>
<td>2.25±0.01c</td>
<td>1.21±0.01a</td>
<td>78.90±0.03c</td>
<td>95.45±0.01a</td>
</tr>
</tbody>
</table>

Values reported as means± standard deviation. Mean value followed by different roman letter are significantly different (p≤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≤0.05. While, total carotenoids ranged from 4.42 to 7.27 mg/100g with significant different (p≤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)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Vitamin C</th>
<th>Total Carotene</th>
</tr>
</thead>
<tbody>
<tr>
<td>10CF</td>
<td>7.92±0.01a</td>
<td>6.96±0.26c</td>
</tr>
<tr>
<td>10CM</td>
<td>8.58±0.93a</td>
<td>5.93±0.18d</td>
</tr>
<tr>
<td>20CF</td>
<td>9.24±1.87a</td>
<td>7.27±0.09a</td>
</tr>
<tr>
<td>20CM</td>
<td>9.90±0.93a</td>
<td>7.12±0.03b</td>
</tr>
<tr>
<td>C0</td>
<td>8.58±0.93a</td>
<td>4.42±0.03e</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Samples</th>
<th>pH</th>
<th>Bulk density</th>
</tr>
</thead>
<tbody>
<tr>
<td>10CF</td>
<td>5.92±0.01b</td>
<td>0.94±0.02a</td>
</tr>
<tr>
<td>10CM</td>
<td>6.03±0.02a</td>
<td>0.94±0.01a</td>
</tr>
<tr>
<td>20CF</td>
<td>5.73±0.02c</td>
<td>0.93±0.02a</td>
</tr>
<tr>
<td>20CM</td>
<td>5.71±0.02c</td>
<td>0.93±0.01a</td>
</tr>
<tr>
<td>C0</td>
<td>5.71±0.01c</td>
<td>0.94±0.02a</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Samples</th>
<th>Colour</th>
<th>Taste</th>
<th>Aroma</th>
<th>Consistency</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>10CF</td>
<td>3.57a</td>
<td>3.57a</td>
<td>3.43a</td>
<td>3.43a</td>
<td>3.29a</td>
</tr>
<tr>
<td>10CM</td>
<td>2.00c</td>
<td>3.00c</td>
<td>2.00c</td>
<td>2.57d</td>
<td>1.86c</td>
</tr>
<tr>
<td>20CF</td>
<td>2.57b</td>
<td>3.00c</td>
<td>3.29b</td>
<td>3.29b</td>
<td>3.00b</td>
</tr>
<tr>
<td>20CM</td>
<td>3.86a</td>
<td>3.86a</td>
<td>3.43a</td>
<td>3.29b</td>
<td>3.14a</td>
</tr>
<tr>
<td>C0</td>
<td>3.29a</td>
<td>3.29b</td>
<td>3.00b</td>
<td>2.71c</td>
<td>3.29a</td>
</tr>
</tbody>
</table>

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](chart.png)
All the samples were not soluble at 60 °C. 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 °C than their 20% blends (Figure 4). The rates of increase in solubility of all the samples were lower between 70 °C and 80 °C than between 80 °C and 90 °C. This means that the samples will require more energy in their preparation as gelatinization may not occur until after 80 °C.

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.

5. REFERENCES


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