Full Paper

PROXIMATE COMPOSITION, MINERAL CONTENT AND SENSORY ASSESSMENT OF AN *IRU* ANALOGUE PRODUCED FROM FERMENTED LIMA BEAN (*PHASEOLUS LUNATUS*)

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ABSTRACT

Search for an alternative raw material for *iru* production informed the fermentation of lima bean to an iru analogue comparable to *iru* from locust bean. The proximate composition, mineral contents and sensory analyses were carried out on fermenting lima bean and locust bean for 72 h. Results showed that protein content increased from 16.81 to 17. 52% and 21.81 to 24.21% o to 72 h in the fermenting lima bean and locust bean respectively. The fat content in both samples also increased with fermentation time. Lima beans fermented for 72 h had significantly lower ($p< 0.05$) carbohydrate compared to the raw lima bean. Processing (roasting, dehulling, cooking) drastically reduced the mineral content (Na, Ca, Mg .P, K, Fe, Zn and Cu) in lima bean but increased with fermentation time. There was no significant difference ($p > 0.05$) in the colour and texture of the whole lima bean iru, laboratory prepared locust bean *iru* and the commercial *iru*. All the three *iru* samples were accepted with no significant difference at 5% level of significance when added to okro soup as a condiment. In conclusion, the study has shown that an *iru* analogue with comparable proximate composition, mineral content and sensory quality as conventional *iru* from locust bean could be produced from lima bean.

Key words: *Iru, fermentation, lima bean, locust bean*

1. INTRODUCTION

Fermentation is an age long method of processing cereals and legumes (Siegel and Faucet, 1978). It modifies some physical characteristics of cereals and legumes, increases level of some nutrients digestibility and bioavailability (WHO, 1998), decreases level of antinutrients, increases nutrient density (Nnam, 1999) and imparts some antimicrobial properties (Mensah *et al*., 1990; Mensah *et al*., 1991). According to Quinn and Beuchat (1975) fermentation of grains and oil seeds results in increased nutritional value and wholesomeness over the starting material. Fermented foods are produced majorly to extend the shelf-life of raw materials and increase their safety. During fermentation, microorganisms play vital roles and contribute to the physico-chemical, sensory and safety characteristics of the final products. They produce organic acids that lower the pH and reduce the growth and survival of pathogenic organisms (Cocolin and Ercolin, 2009). Fermentation also improves the palatability, flavor and nutritive value of the raw seeds (Odunfa, 1985b; Barimalaa *et al*., 1989; Achi and Okereka, 1999).

Condiments are added to soup or sauce to enhance and improve the flavor and taste and also to increase the nutritional status of such foods (Odunfa, 1985c; Aidoo, 1986). *Iru* (*dawadawa*) is a condiment traditionally produced by fermenting locust bean. The fact that locust bean iru is widely accepted (Cambell Platt, 1980) as a cheap source of protein (Odunfa, 1986) implies that other legumes could be exploited to produce this condiment to meet the increasing protein demand (Omafuvbe *et al*., 2000). Lima bean is one of the potential legumes that could be used. Locust beans are obtained from parkia trees (*Parkia biglobossa*), which unfortunately are now getting into extinction because they grow in the wild and this can lead to less availability of locust bean seeds. Lima bean if well improved on the field has a great potential for high yield to compensate for the extinction of parkia trees. Good agronomic practices targeted towards producing the crop has made it more available than parkia which grows in the wild. It has been reported that lima bean could yield excess of 2000 kg per hectare (Rachie *et al*., 1980).Lima bean is nutritious; it is a very good source of protein, fibre, potassium, phosphorous, magnesium, iron, copper, and thiamin (WHO Foods, 2010).

The chemical composition of green and dry lima bean seeds is similar to that of other pulses. Only soybeans and winged beans are richer in oil and protein. According to (Ologhobo and Fetuga 1982) the carbohydrate content is about 63% with the starch content comprising the largest part of about 44% and oligosaccharide comprised of 9.5%. Lima bean contains fairly high potassium and phosphorous with low content of calcium and sodium. Iron, manganese, zinc and copper are present as trace elements (USDA, 1986). The amino acid profile of lima bean is good and remains fairly uniform throughout all wild and cultivated forms. Lima bean is rich in lysine. Like other beans, it is deficient in sulphur containing amino acid (Evans and Bolter 1974).

This study therefore aims at diversifying the use of lima bean by fermenting it into a condiment, evaluate the chemical changes associated with the fermentation process of laboratory prepared *iru* from lima bean and locust bean and their sensory properties in comparison with the traditional commercial *iru*.

2. MATERIALS AND METHODS

2.1. Source of materials

Lima beans were purchased from the Odogbolu main market via Akure, Ondo State, Nigeria. Locust beans and containers (calabash) were obtained at Oje market, Ibadan, Nigeria. Analytical reagents and microbiological media were purchased from a reputable supplier in Ibadan, Nigeria.

2.2. Lima bean fermentation

Lima bean fermentation was carried out according to the method reported by Omafuvbe *et al*.., (2000) with slight modification. Five hundred grams of lima bean seeds were sorted, roasted in open frying pan for 10 min and dehulled. The dehulled beans were cooked with 1000 ml of water for 40 min. The cooked beans were poured while still hot into a clean calabash lined with clean freshly harvested banana leaves. The calabash was covered with another calabash and incubated at 30 ± 5 ^{o}C for 72 *h*. Samples were taken out at 12-hour interval for analysis. The flow chart of lima bean processing for fermentation is shown in Figure 1.

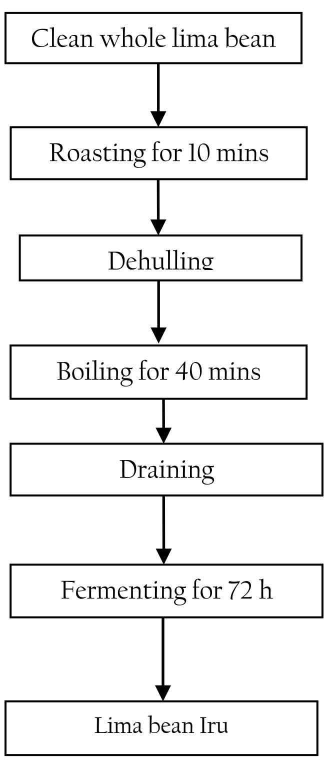

Fig 1: Flowchart of laboratory processing of lima bean Iru

2.3. Locust bean fermentation

Locust bean fermentation was done according to the modified method used by Abiose *et al*. (1986) in which five hundred grams of locust bean seeds were soaked in water overnight (12 h). The soaked beans (with the soaking water 1680 ml) were pressure-cooked for 60 min at 90 kPa pressure in a pressure cooker (MASTER CHEF MC-PC-4060) after which they were dehulled. Dehulling of the beans was done by rubbing in between palms and washing with water and straining through sieve to remove the seed coat. The dehulled beans were again pressure -cooked with 1000 ml of water for 90 min. The cooked beans were poured while still hot into a calabash lined with clean freshly harvested plantain leaves. The calabash was covered with another calabash and was incubated at 30 ± 5 ^{o}C for 72 h. Samples were taken out at 12-hour intervals for analyses. Flow chart of locust bean processing for fermentation is shown in Figure 2.

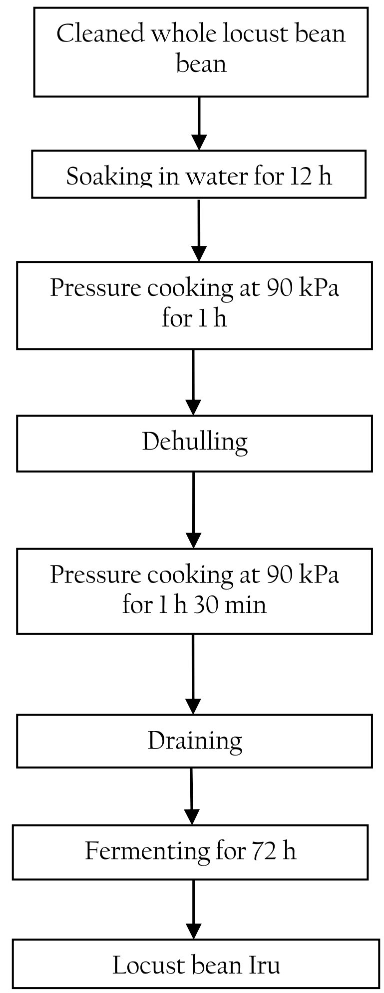

Fig. 2: Flowchart of laboratory processing of locust bean Iru

2.4. Proximate analysis and mineral determination

Proximate composition and mineral content of the samples were determined using the method of (A. O. A. C,. 2000). Samples (2 g) of each was weighed into crucible and transferred into a muffle furnace and they were ashed at 650 ^{o}C for 3 *h*. The ash was removed, cooled in a dessicator and digested with 5ml of 1N HCl for 30 minutes. The digest was filtered with filter paper (Whatman No 1) into a 50ml conical flask. The filtrate was made up to 50ml with distilled water. The content of each flask was shaken vigorously and the mineral element of each sample read in one of flame photometer (Ca, K, Na), SpectrumLab 23A (P), Atomic Absorption Spectrophotometer (Cu, Zn). Readings were compared with those of standards in calibration curves. Values were obtained using the formula:

$$\text{Mineral (ppm)} = \text{Reading x Slope x} \frac{Vol\ of\ extract}{Wt\ of\ sample} \quad (1)$$

Each determination was carried out in triplicate and the mean taken.

2.5. Sensory evaluation

Fresh laboratory prepared lima bean *iru* was compared with laboratory prepared locust bean *iru* and commercial locust bean *iru* in terms of consumer acceptance using a panel of tasters who were familiar with the products. In the first set of the experiments, the three iru samples were coded and presented to the panelists. Another set was used to prepare okro soup separately. The coded whole samples and the coded okro soup samples were presented to ten semi trained panel of judges who were familiar with the traditional locust bean *iru*. The panelists were provided with water for mouth rinsing after each tasting. The panelists were asked to score the samples for colour, appearance, texture, flavor, taste and overall acceptability. The attributes were scored using a 9 point Hedonic scale where 9 = like extremely and 1 = dislike extremely (Larmond, 1977; Iwe, 2002).

2.6. Statistical analysis

Data obtained from the chemical and sensory analysis were subjected to analysis of variance (ANOVA) and the means were separated by Duncan multiple range test (SAS, 2003); significance was accepted at 5 % level.

3. RESULTS AND DISCUSSION

3.1. Changes in the proximate composition of fermented lima bean and locust bean

The moisture content increased with fermentation time in both lima bean and locust bean (Table 1a & 1b). The moisture increased from 29.61% at 0 *h* to 32.42% at *72h and* from 32.61% at 0 *h* to 33.72% at 72*h in* lima bean *iru* and locust bean i*ru* respectively. The increase in moisture content with increase in fermentation time is probably due to the hydrolytic decomposition of the fermenting substrate by the microorganisms (Omafuvbe *et al*., 1999). The fermenting seeds provide moisture that increases the initial humidity for fermentation (Omezuruike, 2008). Processing (roasting, dehulling and cooking) reduced the protein content of lima bean from 21.7% in raw lima bean to 16.18% at 0*h* after cooking (Table 1a). Boiling, dehulling and cooking also reduced the protein content of locust bean from 29.64% in raw locust bean to 21.81% after cooking (Table 1b). This could be due to the fact that the heat applied during roasting and cooking might have denatured some protein and some of the protein could have also been retained in the hull being removed. However the protein content of the fermenting lima bean and locust bean were found to increase with fermentation time from 16.81% at 0*h* to 17.52% at 72*h* and from 21.81% at 0*h* to 24.21% at 72*h* respectively (Tables 1a & 1b). Food fermentation generally increases the protein content or improves the essential amino acid balance in the food (Steinkraus, 1997). Locust bean fermented for 72*h* recorded the highest protein content of 24.21% (Table 1b). Increase in the protein content as fermentation time increased was probably due to the action of microorganisms. During fermentation, microorganisms utilize carbohydrate as energy source and produce carbon dioxide as a byproduct. This process result in the nitrogen in the fermented substrate to become concentrated and thus the protein in the total mass increased (Onyango *et al*., 2004; Ibrahim and Antai, 2005). Increase in microbial density could also have contributed to the increasing protein content with fermentation time since the micro organisms themselves are protein and they are able to synthesize new proteins from the amino acids and shorter peptides. There was no significant difference ($p > 0.05$) in the protein content of lima bean fermented for 60*h* and 72*h*. There was also no significant difference ($p > 0.05$) in the protein content of locust bean fermented for 60*h* and 72*h*.

Table 1a: Changes in Proximate composition of lima bean during fermentation to Iru (%)

Lima bean	Moisture	Protein	Fat	Ash	Crude fibre	Carbohydrate
Raw	14.00 ± 0.1^{g}	21.7 ± 0.1^{g}	2.4 0 ± 0.1^{a}	4.10 ± 0.2^{f}	5.38 ± 0.1^{b}	52.42 ± 0.1^{a}
Hull	8.70 ± 0.1^{h}	1.74 ± 0.1^{e}	0.60 ± 0.1^{g}	3.80 ± 0.1^{a}	43.20 ± 0.3^{a}	41.96 ± 0.0^{b}
0 h	29.61 ± 0.1^{f}	16.81 ± 0.2^{d}	1.30 ± 0.1^{e}	2.41 ± 0.1^{e}	3.25 ± 0.1^{c}	46.52 ± 0.2^{c}
12h	30.25 ± 0.1^{e}	17.01 ± 0.1^{f}	0.42 ± 0.2^{h}	2.55 ± 0.1^{d}	3.41 ± 0.1^{d}	46.36 ± 0.0^{d}
24h	30.86 ± 0.1^{d}	17.33 ± 0.0^{c}	1.01 ± 0.1^{f}	2.59 ± 0.0^{cd}	3.50 ± 0.1^{e}	44.71 ± 0.6^{e}
36h	31.05 ± 0.3^{c}	17.52 ± 0.1^{a}	1.52 ± 0.1^{d}	2.61 ± 0.1^{c}	3.35 ± 0.1^{cd}	43.95 ± 0.1^{g}
48h	31.37 ± 0.1^{b}	17.57 ± 0.1^{a}	1.81\ ± 0.1^{c}	2.62 ± 0.1^{c}	2.25 ± 0.1^{f}	44.38 ± 0.1^{f}
60h	31.42 ± 0.0^{b}	17.90 ± 0.1^{b}	2.17 ± 0.0^{b}	2.67 ± 0.0^{b}	2.27 ± 0.0^{f}	43.89 ± 0.1^{g}
72h	32.42 ± 0.1^{a}	17.52 ± 0.2^{b}	2.17 ± 0.0^{b}	2.68 ± 0.1^{b}	1.48 ± 0.0^{g}	43.73 ± 0.2^{g}

Table 1b: Changes in Proximate composition of locust bean during fermentation to Iru (%)

Locust bean	Moisture	Protein	Fat	Ash	Crude fibre	Carbohydrate
Raw	14.15 ± 0.1^{f}	29.64 ± 0.0^{a}	19.10 ± 0.1^{a}	4.34 ± 0.4^{a}	5.21 ± 0.1^{a}	27.56 ± 0.3^{a}
Hull	24.32 ± 0.3^{e}	7.22 ± 0.2^{f}	3.21 ± 0.0^{b}	1.40 ± 0.4^{f}	2.91 ± 0.1^{e}	41.90 ± 0.3^{b}
0h	32.63 ± 0.3^{bc}	21.81 ± 0.1^{de}	12.66 ± 0.1^{c}	2.50 ± 0.1^{e}	3.42 ± 0.1^{b}	27.00 ± 0.0^{c}
12h	32.66 ± 0.1^{bc}	22.00 ± 0.2^{e}	12.96 ± 0.1^{cd}	2.67 ± 0.1^{b}	3.33 ± 0.1^{c}	26.38 ± 0.1^{c}
24h	32.82 ± 0.1^{c}	22.67 ± 0.2^{d}	12.38 ± 0.0^{d}	2.68 ± 0.0^{c}	3.20 ± 0.0^{bc}	26.25 ± 0.1^{d}
36h	32.55 ± 0.1^{b}	23.10 ± 0.0^{d}	13.39 ± 0.2^{e}	2.67 ± 0.2^{b}	3.20 ± 0.1^{bc}	25.09 ± 0.2^{e}
48h	32.46 ± 0.1^{d}	24.00 ± 0.1^{b}	13.75 ± 0.1^{g}	2.70 ± 0.1^{bc}	2.12 ± 0.0^{g}	23.97 ± 0.1^{f}
60h	33.51 ± 0.0^{a}	24.01 ± 0.0^{b}	13.90 ± 0.1^{f}	2.70 ± 0.0^{bc}	2.00 ± 0.2^{f}	23.88 ± 0.0^{f}
72h	33.72 ± 0.0^{a}	24.21 ± 0.0^{c}	13.82 ± 0.1^{f}	2.80 ± 0.0^{d}	1.65 ± 0.2^{d}	23.80 ± 0.1^{f}

Mean in the same column followed by the same letter are not significantly different at 5% significant level.

Processing also reduced the fat content in both samples. Fat content reduced from 2.40% in the raw lima bean to 1.30% after cooking and from 19.10% in the raw locust bean to 12.66% after cooking. But it also increased with fermentation time. The ether extract ranged between 1.30% at 0*h* to 2.17% at 72*h* and from 12.66% at 0hr to 13.82% at 72*h* of fermentation in lima bean and locust bean, respectively (Table 1a &1b). Similar increase in ether extract with fermentation r was reported by (Achinewu and Isichei, 1990; Obizoba and Atii, 1991) on flutted pumpkin and sorghum seeds respectively. The raw lima bean is very low in fat (2.40%) and this even decreased to 2.17% at both 60*h* and 72*h* of fermentation. Low fat content in fermented lima bean agrees with the finding of (Fasoyiro *et al*., 2009) on the development of pigeon pea to *dawadawa*. It was reported that pigeon pea *dawadawa* had a lower fat content when compared with soyabean and locust bean. Lower fat content in lima bean gives an advantage over high fat proteinous diet and the lima bean *iru* may stay longer on shelve due to its low fat content which may reduce the extent of occurrence of rancidity.

The result of the ash content of both samples at 0*h* of fermentation shows that most of the ash was contained in the hull (Tables 1a &1b). Lima bean hull contained a significantly high ($p < 0.05$) ash content (3.80%) compared with that of locust bean (1.40%). The result also shows that heat process probably affected the ash content in both samples because the ash content reduced from 4.10% in raw lima bean to 2.41% after cooking prior to fermentation and from 4.3% in raw locust bean to 2.50% after cooking before fermentation. However, the ash content was improved with fermentation. The ash content increased from 2.41% at 0*h* to 2.68% at 72*h* and from 2.50% at 0*h* to 2.80% at 72*h* in the fermenting lima bean and locust bean respectively (Table 1a, 1b). Concomitant increase observed in mineral content of the fermenting lima bean and iru over the period of fermentation agrees with these finding. Metabolic activities of microbes associated with fermentation could have caused synthesis of some elements which could have been responsible for the slight increases observed in ash content. This finding is in contrast with the findings of Quinn and Beuchart (1975) and Nnam and Obiakor (2003) during the fermentation of peanut and baobab seeds respectively in which ash content decreased with fermentation.

Crude fibre decreased with fermentation time in both samples. It decreased from 3.25% at 0hr to 1.48% at 72*h* of fermentation, and from 3.42% at 0*h* to 1.65% at 72*h* of fermentation in lima bean and locust bean respectively (Tables1a &1b). The hull of lima bean was significantly high ($p < 0.05$) in crude fibre than the hull of locust bean, this could probably be due to the different methods employed in processing them. There was no significant difference ($p > 0.05$) in the crude fibre of lima bean and locust bean fermented for 72*h*. Liberation of cellulolytic enzymes by the fermenting microbes could have caused a reduction in the fibre content over the period of fermentation.

Carbohydrate content also decreased with fermentation time in both samples. Carbohydrate decreased from 46.52% at 0*h* to 43.73% at 72*h* and from 27.0% at 0*h* to 23.80% at *72h of* fermentation in lima bean and locust bean respectively (Tables 1.1a &1.1b). There was no significant difference ($p > 0.05$) in the carbohydrate content of the hull of lima bean and hull locust bean. Raw lima was significantly higher ($p < 0.05$) in carbohydrate than the raw locust bean. Similar observation of decreased carbohydrate content with fermentation was reported by Achinewu and Isichei (1990) and Nnam (1995) on fermented fluted pumpkin seeds and fermented cowpea respectively. The decrease could have been attributed to increased activity of amylolytic enzymes which hydrolyze starch and other carbohydrates to simple sugars or other compounds which were utilized as carbon and energy sources by fermentation microorganisms (Kazanas and Fields, 1981)

3.2. Changes in the mineral composition of the fermented lima bean and locust bean with fermentation

The mineral content of both lima bean and locust bean increased with fermentation time (Tables 2a & 2b). The macro nutrients (Na, Mg, P, K and Ca) were generally high although calcium content was not as high as the others. The micro nutrients (Fe, Zn and Cu) were low. Oboh (2006) reported high content of macronutrients in condiments produced from some under – utilized legumes (soybean, melon, pigeon pea). The raw lima bean recorded the highest sodium content (2300 ppm). Dehulling and processing drastically reduced the sodium level from 2300 ppm in the raw lima bean to 140 ppm at 0*h*. Fermentation increased the sodium level from 140 ppm at 0 h to 1100 ppm at 72*h* in the fermenting lima bean (Table 2a).

Table 2a: Mineral composition of fermenting lima bean (ppm)

Lima bean	Na	Ca	Mg	P	K	Fe	Zn	Cu
Raw	2300 ± 67^{a}	500 ± 16^{a}	8100 ± 50^{a}	8400 ± 16^{a}	2100 ± 50^{e}	1.21 ± 0.01^{g}	0.17 ± 0.0^{a}	1.33 ± 0.00^{a}
Hull	900 ± 16^{d}	400 ± 07^{b}	4800 ± 00^{f}	3500 ± 27^{g}	900 ± 20^{g}	1.10 ± 0.04^{c}	0.17 ± 0.0^{e}	1.24 ± 0.01^{c}
0h	140 ± 67^{b}	210 ± 03^{c}	6900 ± 03^{e}	6100 ± 16^{e}	1400 ± 00^{f}	1.01 ± 0.01^{f}	0.11 ± 0.01^{e}	0.61 ± 0.01^{g}
12h	1000 ± 33^{e}	200 ± 00^{c}	13000 ± 0^{b}	5500 ± 66^{f}	2200 ± 20^{d}	1.15± 0.01^{d}	0.14 ± 0.01^{d}	1.00 ± 0.00^{f}
24h	800 ± 33^{f}	200 ± 00^{c}	8800 ± 04^{c}	6200 ± 33^{e}	2500 ± 16^{c}	1.16 ± 0.02^{b}	0.14 ± 0.0^{d}	1.13 ± 0.02^{e}
36h	800 ± 00^{f}	200 ± 00^{c}	10500 ± 5.0^{e}	6270 ± 06^{d}	2550 ± 01^{b}	1.18 ± 0.01^{a}	0.15 ± 0.01^{c}	1.15 ± 0.00^{e}
48h	1000 ± 06^{cd}	200 ± 05^{c}	10620 ± 00^{d}	7000 ± 17^{c}	2800 ± 34^{a}	1.13 ± 0.01^{dc}	0.15 ± 0.01^{c}	1.32 ± 0.01^{ab}
60h	1100 ± 05^{c}	200 ± 00^{c}	10620 ± 00^{d}	7480 ± 03^{b}	2800 ± 01^{a}	1.19 ± 0.01^{a}	0.16 ± 0.01^{b}	1.30 ± 0.00^{b}
72h	1100 ± 00^{c}	200 ± 00^{c}	11400 ± 00^{g}	7482 ± 02^{b}	2600 ± 16^{b}	1.10 ± 0.01^{c}	0.17 ± 0.01^{a}	1.30 ± 0.01^{b}

Table 2b: Mineral composition of fermenting Locust bean (ppm)

Locust bean	Na	Ca	Mg	P	K	Fe	Zn	Cu
Raw	2100 ± 01^{a}	650 ± 10^{a}	5800 ± 03^{d}	12400 ± 01^{b}	5100 ± 50^{c}	1.02 ± 0.01^{b}	0.11 ± 0.01^{a}	1.26 ± 0.00^{e}
Hull	600 ± 00^{d}	100 ± 06^{f}	4200 ± 06^{e}	3700 ± 02^{g}	700 ± 01^{f}	0.11 ± 0.00^{c}	0.07 ± 0.01^{c}	0.81 ± 0.01^{d}
0h	1100 ± 04^{c}	500 ± 10^{b}	4100 ± 01^{f}	8400 ± 04^{e}	2800 ± 20^{e}	0.12 ± 0.01^{c}	0.05 ± 0.01^{d}	0.90 ± 0.00^{d}
12h	1400 ± 0^{b}	100 ± 10f	6200 ± 09^{c}	7100 ± 00^{f}	4200 ± 01^{d}	1.00 ± 0.01$_{b}$	0.07 ± 0.00^{c}	0.62 ± 0.02^{c}
24h	1100 ± 03^{c}	300 ± 04^{d}	6200 ± 01^{c}	8400 ± 10^{e}	4200 ± 0^{d}	1.10 ± 0.00^{d}	0.07 ± 0.00^{c}	1.09 ± 0.02^{b}
36h	1100 ± 0^{c}	300 ± 00^{d}	6200 ± 0^{c}	8720 ± 01^{d}	5120 ± 07^{c}	1.20 ± 0.01^{e}	0.07 ± 0.01^{c}	1.09 ± 0.01^{b}
48h	1100 ± 0^{c}	200 ± 03^{e}	6500 ± 17^{b}	10100 ± 00^{c}	6200 ± 02^{b}	1.00 ± 0.01^{b}	0.09 ± 0.01^{b}	1.09 ± 0.01^{b}
60h	1100 ± 06^{c}	400 ± 05^{c}	8200 ± 0^{a}	12800 ± 0^{a}	6200 ± 34^{b}	1.15 ± 0.01^{a}	0.11 ± 0.01^{a}	1.13 ± 0.01^{a}
72h	1100 ±16^{c}	400 ± 00^{c}	8200 ± 00^{a}	12800 ± 00^{a}	6900 ± 34^{a}	1.15 ± 0.01^{a}	0.11 ± 0.01^{a}	1.13 ± 0.01^{a}

Mean in the same column followed by the same letter are not significantly different at 5% significant level.

Increase in the sodium level with fermentation could be due to activity of the fermenting microorganisms. The result of the calcium content on the fermenting lima bean showed that only processing had significant effect on the calcium level, fermentation had no effect on the calcium level because there was no significant effect ($p > 0.05$) of fermentation time on the calcium content of lima bean from 0*h* to 72*h*. Fermentation increased the magnesium content in the fermenting lima bean from 6900 ppm at 0 hr to 11400 ppm at 72*h*. There was no significant difference ($p < 0.5$) in the Mg content of lima bean fermented for 36*h*, 48*h*, 60*h* and 72*h*. Magnesium content of both fermented lima bean and locust bean reported in this study are higher than the magnesium content reported (Akindahunsi and

Oboh, 1999; Omafuvbe *et al*., 2002) in fermented vegetables and fermented soybean, respectively. Phosphorus and potassium content also increased with fermentation in the fermenting lima bean. They increased from 6100ppm at 0*h* to 7482 ppm at 72*h* and from 1400 ppm at 0*h* to 2600 ppm at 72*h* respectively (Table 2a). Fermentation increased the potassium content over and above the value recorded in the raw lima bean. Iron content was slightly reduced after dehulling. Fermentation had no remarkable effect on the Fe content of the lima bean. There was no significant difference ($p > 0.05$) in the zinc content of the raw lima bean and the lima bean fermented for 72*h* which is an indication that fermentation has no significant effect on the zinc content of the lima bean. Fermentation also had no significant effect on the copper content of the fermenting lima bean (Table 2a).

Processing (dehulling and cooking) reduced the sodium content in the fermenting locust bean from 2100ppm in the raw locust bean to 1100 ppm at 0*h* after cooking. Fermentation slightly increased the Na level to 50% of what was obtained in the raw lima bean (Table 2b). Both processing and fermentation reduced the calcium level from 650 ppm in the raw locust bean to 400 ppm in the locust bean fermented for 72*h*. Processing had a reducing effect on the magnesium content of locust bean from 5800 ppm in the raw locust bean to 4100 ppm at 0 hr but fermentation increased the magnesium content even to a level higher than that of the raw locust bean (8200 ppm). Fermentation also increased the phosphorous content in locust bean to a level slightly higher than that of the raw. Locust bean fermented at 48, 60 and 72*h* were significantly higher ($p < 0.05$) in phosphorous and potassium respectively when compared with other samples. Processing and fermentation increased the iron content in locust bean. The iron content ranged between 1.02 ppm in the raw locust bean to 1.15 ppm in the locust bean fermented for 72*h* (Table 2b). Fermentation had no effect on the zinc content in locust bean too. This is because there was no significant effect ($p > 0.05$) in the zinc content of the raw locust bean and the locust bean fermented for 72*h*. Fermentation slightly reduced the copper content of the locust bean.

The importance of these elements in human health has been documented. The fact that fermentation reduced the effect of processing on these beans has been established in this study. Lima bean is known to be a major source of magnesium and potassium (Anon, 2011). Fermentation increased magnesium and potassium content by about 40% and 24% respectively. These increases will ensure that RDA of these elements is catered for by consumption of fermented lima bean regardless of the quantity lost during dehulling and cooking. Even in other elements where overall amounts in fermented products were less than those of the raw beans, fermentation increased their quantity with time.

3.3. Sensory evaluation of the fermented lima bean, locust bean and the commercial locust bean *iru*.

The result of the sensory evaluation of the whole fermented lima bean, locust bean and commercial locust bean *iru* is shown in Table 3a. In terms of color and texture, there was no significant difference ($p > 0.05$) in the three *iru* samples. Lima bean *iru* was adjudged comparable to the laboratory made locust bean *iru* and the commercial iru in terms of appearance. However the panelists rated it lower to the laboratory prepared locust bean *iru* and the commercial *iru* in terms of flavor. There was no significant difference ($p > 0.05$) in the color and the texture of the three samples. This is an indication that fermentation process improves the softness of the lima bean compared to the longer cooking time which reduces its utilization. Softening of the seeds during fermentation is associated with activities of galactanase enzyme (Achi, 2005). All the three samples were accepted but the commercial locust bean *iru* was most preferred.

3.4. Sensory evaluation of the fermented lima bean *iru*, locust bean *iru* and the commercial locust bean *iru* as condiment added to okro soup.

The result of the sensory evaluation of lima bean *iru*, locust bean *iru* and the commercial *iru* when added as condiment to okro soup is shown in Table 3.3b. Lima bean *iru* compared favorably well with the locust bean *iru* and the commercial *iru* in okro soup in terms of colour, flavour, and texture. Lima bean *iru* was even rated higher in terms of texture than the other two samples. This could be due to the soft texture of the fermented lima bean. There was no significant difference ($p > 0.05$) in the flavor and taste of laboratory prepared lima bean and locust bean *iru* as condiment in okro soup. All the three samples were accepted with no significant difference at 5% level of significance.

Table 3a: Sensory evaluation of whole lima bean iru, locust bean iru and commercial locust bean iru

Sample	Color	Appearance	Flavor	Texture	Taste	Overall acceptability
A4	5.80^a	5.80^b	5.00^b	5.60^a	5.10^b	5.70^b
Ap	5.50^a	5.50^{ab}	4.70^b	5.10^a	4.80^b	5.60^b
Ao	7.10^a	7.20^a	7.30^a	7.00^a	7.80^a	7.70^a

Mean in the same column followed by the same letter are not significantly different at 5% significant level.

Key: A4 = Locust bean iru; Ap = Lima bean iru; Ao = commercial iru

Table 3b: Sensory evaluation of lima bean iru, locust bean iru and commercial locust bean iru as condiment added to okro soup

Sample	Color	Appearance	Flavor	Texture	Taste	Overall acceptability
A4	7.10^a	6.90^a	5.10^b	6.50^a	5.80^a	6.50^a
Ap	5.30^b	4.60^b	6.20^{ab}	6.30^{ab}	5.50^a	5.40^a
Ao	6.40^{ab}	6.60^a	7.10^a	5.10^b	5.50^a	6.40^a

Mean in the same column followed by the same letter are not significantly different at 5% significant level

Key: A4 = Locust bean iru; Ap = Lima bean iru; Ao = commercial iru

4. CONCLUSION

The study showed that iru analogue could be produced from lima bean. Processing operations such as roasting, dehulling and cooking were found to reduce the nutrients contained in the raw lima and locust beans. However fermentation was found to improve the proximate and the mineral content of the fermented lima bean and locust bean. No significant difference was observed in the flavor and taste of the laboratory prepared lima bean and locust bean when added to okro soup as condiment. Lima bean *iru* compared favorably well with laboratory prepared locust bean *iru* and the commercial *iru* in all the sensory qualities tested. Lima bean could serve as alternative raw material to locust bean for production of *iru*.

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