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Full length Research paper

Utilization of jack beans *(Canavalia ensiformis)* for human consumption in Tanzania

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Population increase is forcing mankind to look for alternative food sources from underutilized plants. Jack bean has been earmarked as one of these food sources. The only barrier for its utilization is the presence of inherent toxic compounds that should be removed, to make it edible to humans. A number of researchers have tried various ways in an effort to reach that goal. This study has also tried to perform a number of treatments on jack beans, which included soaking, treatment with trona (magadi soda) and germination. The samples of jack beans were brought from Mlingano Agricultural Research Institute and transported to the Sokoine University of Agriculture, Tanzania. Proximate analysis, mineral and phenolic compounds content were carried out on the treated samples. Acceptability tests were performed on products prepared from composite flour, made from 48 h. germinated jack beans. The products included porridges, breads and buns. Soaking results in lowering mineral concentrations. However, treatment with trona increased mineral profile. The levels of calcium, iron and zinc for the jack bean seeds analysed, gave 8.99, 3.83 and 1.76 mg/100 g, respectively. Proximate analysis revealed that moisture, protein, fibre, fat, ash and carbohydrate content were 4.6, 29.7, 5.2, 3.3, 3.4 and 53.9%, respectively. Phenolic compounds concentrations continued to decrease gradually with various treatments. Soaking had minimal effect in reducing phenolic compounds but, germination of jack beans for 48 h. had the highest (82%) reduction effect. There were significant differences (P ≤ 0.05) in organoleptic properties with regards to breads and porridges but no significant differences (P ≥ 0.05) in all organoleptic properties with respect to the buns. Panelists liked the buns much more compared to the breads and porridges. There were no complaints from all the panelists after consuming the jack bean based products. This outcome shows the potential of jackbean being used as a human food in the near future especially using germinated flour. The reports from researchers that jack beans are consumed by some ethnic groups and personal narrations of people who have consumed the beans, if followed up and comprehend the way they do their preparation, will be a great stride towards utilization of jack beans.

Key words: Jack beans, anti-nutritional factors, phenols, germination, soaking, trona.

INTRODUCTION

The population of the world is increasing at an alarming rate. Competition for food and feed for human and animal consumption especially protein sources will continue to rise. Large population in developing countries suffers

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varying degree of malnutrition because, protein rich food such as meat, milk, fish are expensive to acquire (Abitogun and Olasehinde, 2012; Adebowale et al., 2005). In addition, tropical developing countries are facing an increasing demand for protein rich foods due to increase in population, increased consumption of cereal based foods share and increased scarcity of fertile land. It is therefore imperative to look for other sources of proteins such as the underutilized legumes. One of these sources is *Canavalia ensiformis* commonly known as Jack bean. Raw *Canavalia* seeds contain about 300 g kg^{-1} protein and 600 g kg^{-1} carbohydrates (Rajaram and Janardhanam, 1992). Jack bean belongs to the kingdom Plantae, Division Magnoloiphyta, Order Fabales, subsided Family Fabaceae/Leguminosae, Genus *Canavalia* and Species *C. ensiformis* (USDA, 2005). The genus *Canavalia* comprises 48 species of underutilized annual legumes widely distributed and indigenous to the tropics and they are rarely edible to man and under optimal agronomic conditions unless there are processed. However, India Doss et al. (2011a) reports that, mature beans are consumed by some tribal sects. In western countries this legume is used as a cover crop and the roasted seeds are ground to prepare coffee-like drink (Bressani et al., 1987). In Nigeria *C. ensiformis*, is currently grown as ornamental plant, planted near houses and allowed to trail on walls and trees, believed to repel snakes (Abitogun and Olasehinde, 2012). Many researchers have been investigating on how to make jack beans edible to human beings by using various treatments like heating, fermentation and extrusion but without obtaining favourable results (Justo et al., 1994). This is because there are a number of antinutritional factors present in jack beans, which restricts its utilization as human food. These factors include; thermo-stable factors (canavanine, concanavalin, canavalin, canatoxin) and thermo-labile factors protease inhibitors, lectins and phytic acid (Carlini and Udedibie 1997; Udedibie and Carlini 1998).

Another study has been going on in Muheza district, Tanzania Mlingano Agricultural Research station on the use of *C. ensiformis* as green manure where the plant has shown potential in contributing about 98 kg N per ha to the soil and, increased maize yield from 1.4 to 2.5 t/ha and substantially reduced striga weed numbers (Figure 2). Okonkwo and Udedibie (1991) reported similar yields whereby a total yield of dry seeds reached up to 2.5 tons ha^{-1}. However, despite this outstanding performance by this technology, adoption by farmers around the research station has been very slow because farmers got discouraged for growing a crop that cannot be consumed. This study sought to look for options of utilization of jack beans for human consumption contrary to the way it is being used now as green manure and cover crop.

METHODOLOGY

Raw materials and preliminary handling

About 40 kg of jack beans (Figure 3) were brought from Mlingano Agricultural Research Institute, Muheza, Tanzania and transported to Sokoine University of Agriculture, Department of Food Technology, Nutrition and Consumer Sciences. They were sorted by removing extraneous material. The beans were sealed into plastic bags and stored at room temperature (≈25°C) until laboratory analysis. Acceptability studies were carried out on a number of recipes developed from jack beans. Various treatments were employed on jack bean seeds, in an effort to find ways that are normally practiced in households to make the beans utilizable. These treatments included soaking for varying time, boiling with/without outer coat removed, boiling with soda ash at various concentration and germination at varying times as presented in Table 1.

Oven dried jack bean seeds

About 2.0 kg of jack bean seeds were washed and oven dried at 105°C for 24 h.

Soaked jack bean seeds

A total of 8.0 kg of jack bean seeds were washed and soaked for 3 to 6 h. in distilled water to imbibe adequate water (ratio 1:4 bean: water) at room temperature (≈25°C). About 2 kg each were given treatments as presented in Table 1. Decortication of the beans was done by hands after the soaking process.

Boiled jack bean seeds

About 12 kg of Jack beans were washed and boiled for 1 h (ratio 1:5 bean: water). The one hour was counted from when the water started to boil reaching a temperature of 100°C. About 2 kg each were given treatments as presented in Table 1.

Germinated Jack bean seeds

A total of 15.0 kg of jack bean seeds were washed and soaked for 8 h. (ratio 1:4 bean: water) in distilled water to imbibe adequate water at room temperature (≈25°C). The seeds where then covered in a clean bloating paper germinated in the absence of light at a temperature of 37°C for 5 days. The germination process was stopped before the photosynthetic activity, by drying them in oven maintained at 105°C for 24 h. About 2 kg each were given treatments as presented in Table 1.

Proximate analysis of the samples

The bean samples for chemical analysis were ground to pass through a one millimetre screen in a Christy and Norris 20 cm laboratory Hammer Mill (London). Dry Matter percentage (%DM)

Table 1. Sample Treatment

Sample	Sample treatment	Code
i	Control: Oven dried and milled	A
ii	3 h soaking, outer coat removed, oven dried and milled	B
iii	6 h soaking, outer coat removed, oven dried and milled	C
iv	3 h soaking, oven dried and milled	D
v	6 h soaking, oven dried and milled	E
vi	1 h boiled, outer coat removed, oven dried and milled	F
vii	1 h boiled, outer coat removed, oven dried and milled	G
viii	1 h boiled in 5 % Soda ash, oven dried and milled	H
ix	1 h boiled in 10 % Soda ash, oven dried and milled	I
x	1 h boiled in 5 % Soda ash, outer coat removed, oven dried and milled	J
xi	1 h. boiled in 10 % Soda ash, outer coat removed, oven dried and milled	K
xii	Bean seeds, soaked for 8 h., 24 h. germinated oven dried and milled	L
xiii	Bean seeds, soaked for 8 h., 36 h. germinated oven dried and milled	M
xiv	Bean seeds, soaked for 8 h., 48 h. germinated oven dried and milled	N
xv	Bean seeds, soaked for 8 h., 72 h. germinated oven dried and milled	O

was determined by drying the sample in an oven at 103 to 105°C for 24 h. Crude protein percentage (% CP) was determined by Kjeldahl method AOAC method No. 920.87 (AOAC, 1995) with the Kjeltec auto 1030 analyser, Tecator (Sweden) and percentage nitrogen obtained was used to calculate the % CP using the relationship: % CP = % N × 6.25 (Ahenkora et al., 1998). Ether extract percentage (% EE) was determined using the Soxlet System HT- extraction technique AOAC method No. 922.06 (AOAC, 1995) and percentage ash (% minerals) was determined after the dry matter determination by incinerating the samples in a muffle furnace at 550°C for four hours. The ash was cooled in desiccators and then weighed. Crude fibre percentage (% CF) was determined by the fibre system and Weende method (AOAC, 1995). Nitrogen free extract percentage (%NFE) was calculated by difference: thus %NFE = 100 - (% moisture + %CP + % EE + % CF + % Ash).

Mineral content of the samples

Total mineral content of bean samples were carried out after dry ashing. The ashes of the various treated samples were dissolved in 10 ml of concentrated hydrochloric acid. Total calcium, iron and zinc were determined by atomic absorption spectrophotometer using an AOAC method No 970.12 (AOAC, 1995) and mineral concentrations were read from Shimadzu Atomic Absorption Spectrophotometer (AAS) (UNICAM 919, England).

Polyphenols in bean samples

About 0.5 g of milled bean sample was boiled with 20 ml distilled water at 100°C for 15 min. The resulting boiled sample was filtered using Whatman filter paper No. 1. Filtrate was then transferred to a 50 ml volumetric flask and diluted to 50 ml mark. 1ml of each sample extract and each standard concentration was taken into 100 ml volumetric flask in triplicate. Blank solution was prepared by taking 1 ml distilled water instead of the standard or sample. Exactly 70 ml of distilled water was added, followed by the addition of 5 ml of 2N Folin Ciocalteus reagent. The mixture was swirled and incubated at room temperature (25°C) for 10 min. Then 15 ml of Sodium Carbonate solution were added, diluted to 100 ml mark with distilled water and incubated for 2 h at room temperature. Absorbance was read at 765 nm using Wagtech CECIL 2021 UV-visible spectrophotometer and the amount of polyphenols were calculated using the equation obtained from the standard plot (Gallic acid) obtained from Merk Schuchardt OHG, German.

Preparation of the taste panel products, acceptability studies and ethical clearance

Since it was risky to use Jack bean flour straight from the unprocessed seeds due to inherent toxicity, the products made from jack bean composite flour were porridges, buns and breads, which were obtained from jack bean that was germinated for 48 hours (Tables 1 to 3). This is because at 48 h the polyphenols were at their lowest level. The taste panel consisted of undergraduate students from the Department of Food Technology, Nutrition and Consumer Sciences. The undergraduate students have been trained to conduct sensory evaluations as part of their course and have been involved in several evaluations done frequently at the department. Ethical permission was provided by the Sokoine University of Agriculture.

Written consent was sought from the students, for their willingness to participate in the study. They were also informed of the possible effects that they might feel after ingesting the jack bean composite flour products such as feeling drowsy or tiredness. They were monitored for any physiological discomfort or any other ill feeling. The panellists were instructed to sip water before and after assessing each product. The panellists recorded sensory characteristics of each sample using a 7-point hedonic scale as described by (Lawless and Heymann, 2010) where 1 = like extremely, 2 = like very much 3 = like moderately, 4 = like slightly, 5 = neither like nor dislike, 6 = dislike slightly and 5 =dislike most. Variables tested were flavour, smell, taste, colour, and general acceptability.

The formulations, which were subjected to sensory evaluation included porridges, breads and buns (Tables 2, 3 and 4). The mixing ratio of either jack bean: maize or jack bean: wheat flour was 5, 10, 15, 20 and 25 to 95, 90, 85, 80 and 75, respectively. The total amount of the preparations was computed based on the aforementioned ratios. The composition of each preparation was based on how each formulation is often prepared in households.

Table 2. Preparation of composite flour (jack bean: maize) porridges.

Samples	Composition (%)			Code
Porridge	Bean flour	Maize flour	Total	
Ratios (%)	5	95	100	JKPORRIDGE 0595
	10	90	100	JKPORRIDGE 1090
	15	85	100	JKPORRIDGE 1585
	20	80	100	JKPORRIDGE 2080
	25	75	100	JKPORRIDGE 2575

Table 3. Preparation of composite flour (jack bean: wheat) breads.

Samples	Composition (%)						Code
Breads	Bean flour	Wheat flour	Total	Yeast (g)	Salt (g)	Oil (ml)	
Ratios (%)	5	95	100	10	7	20	JKBREAD0595
	10	90	100	10	7	20	JKBREAD 1090
	15	85	100	10	7	20	JKBREAD 1585
	20	80	100	10	7	20	JKBREAD 2080
	25	75	100	10	7	20	JKBREAD 2575

Table 4. Preparation of composite flour (jack bean: wheat) buns

Samples	Composition (%)						Code
Buns	Bean flour	Wheat flour	Total	Sugar (g)	Yeast (g)	Salt (g)	
Ratios (%)	5	95	100	100	10	5	JKBUNS 0595
	10	90	100	100	10	5	JKBUNS 1090
	15	85	100	100	10	5	JKBUNS 1585
	20	80	100	100	10	5	JKBUNS 2080
	25	75	100	100	10	5	JKBUNS 2575

Data analysis

Data obtained were entered and subjected to statistical analysis using statistical package and service solution (SPSS) computer software version 16 to compute descriptive and inferential statistics. Descriptive statistics were run to obtain measures of central tendency. Analysis of variance of the results was done at 95% confidence interval (P≤0.05) using Turkeys Honestly Significant Difference. Homogeneity test was performed to determine homogenous sets.

RESULTS

Proximate composition of various jack bean treatments

The proximate composition of the various treatments employed on jack bean seeds are presented in Table 5:. Moisture ranged from 3.83 ± 0.31 to 7.17 ± 0.01% while protein ranged from 24.44 ± 0.03 to 29.69 ± 0.07%. The fibre content varied a lot between treatments where the seed coat was removed and to those which the seed coat was retained. The fat, ash and carbohydrate contents did not differ much between treatments.

Mineral profile of various jack bean treatments

The mineral profile for the various jack bean treatments is presented in Table 6. Soaking resulted in lowering mineral concentrations. Removal of the outer coat further reduced mineral concentration probably due to leaching and some amount of minerals that were present in the seed coat. However, treatment with trona showed significant increase in minerals, which might have been contributed to the mineral composition of the trona. The increase was consistent with increase in trona concentration that is, 5% to 10%.

Table 5. Proximate composition of jack bean treated samples

Sample Code[1]	% Moisture	% Protein	% Fibre	% Fat	% Ash	% Carbohydrate
A	4.63 ± 0.02	29.69 ± 0.07	5.15 ± 0.28	3.28 ± 0.07	3.37 ± 0.01	53.88 ± 0.27
B	4.31 ± 0.02	28.2 ± 0.07	3.11 ± 0.13	3.20 ± 0.01	3.50 ± 0.01	57.51 ± 0.26
C	3.94 ± 0.05	28.07 ± 0.12	1.99 ± 0.02	3.18 ± 0.09	3.51 ± 0.02	59.30 ± 0.89
D	3.83 ± 0.31	26.07 ± 0.02	10.94 ± 0.49	3.39 ± 0.03	3.33 ± 0.11	52.43 ± 0.00
E	4.10 ± 0.25	29.57 ± 0.11	9.31 ± 0.00	3.21 ± 0.01	3.46 ± 0.03	50.31 ± 0.12
F	4.66 ± 0.45	25.07 ± 0.07	13.36 ± 0.66	3.38 ± 0.11	3.24 ± 0.01	50.27 ± 0.26
G	3.99 ± 0.05	28.21 ± 0.07	1.73 ± 0.34	3.21 ± 0.00	3.16 ± 0.05	59.68 ± 0.39
H	5.32 ± 0.00	29.4 ± 0.21	2.13 ± 0.14	3.27 ± 0.05	4.39 ± 0.01	55.45 ± 0.38
I	4.76 ± 0.02	25.02 ± 0.07	5.24 ± 0.63	3.28 ± 0.00	4.12 ± 0.04	57.56 ± 0.16
J	4.51 ± 0.17	29.33 ± 0.00	2.72 ± 0.07	3.95 ± 0.02	3.49 ± 0.01	55.98 ± 0.25
K	4.30 ± 0.17	28.01 ± 0.02	2.06 ± 0.21	3.14 ± 0.04	4.85 ± 0.44	57.61 ± 0.45
L	7.08 ± 0.01	25.87 ± 0.18	7.20 ± 0.14	3.15 ± 0.08	3.51 ± 0.09	53.17 ± 0.52
M	7.02 ± 0.01	24.82 ± 0.02	9.21 ± 0.02	3.21 ± 0.01	3.35 ± 0.00	52.36 ± 0.02
N	6.91 ± 0.03	25.47 ± 0.16	7.59 ± 0.49	3.33 ± 0.35	3.48 ± 0.09	53.20 ± 0.64
O	7.15 ± 0.01	24.44 ± 0.03	8.95 ± 0.09	3.14 ± 0.09	3.41 ± 0.07	52.88 ± 0.14

[1]Check Table 1.

Table 6. Mineral content of the various treated samples.

Sample Code[1]	Ca (ppm)	Fe (ppm)	Zn (ppm)
A	8.99±0.03	3.83±0.02	1.76±0.06
B	7.09±0.02	2.87±0.02	1.55±0.04
C	6.64±0.01	2.66±0.06	1.46±0.07
D	6.41±0.03	3.26±0.02	1.59±0.01
E	5.35±0.02	2.70±0.01	1.23±0.02
F	8.52±0.05	3.03±0.01	1.53±0.01
G	7.18±0.02	3.36±0.01	1.58±0.04
H	12.69±0.07	6.43±0.03	4.31±0.01
I	13.81±0.04	7.04±0.06	4.83±0.01
J	11.18±0.04	6.49±0.02	4.38±0.03
K	13.21±0.02	8.01±0.02	4.45±0.06
L	7.29±0.02	3.44±0.02	1.65±0.01
M	7.18±0.02	3.14±0.06	1.42±0.01
N	6.78±0.07	3.55±0.06	1.54±0.01
O	8.13±0.03	3.51±0.01	1.32±0.01

[1]Check Table 1.

Phenolic compounds content of various jack bean treatments

The untreated sample had the highest phenol compounds (841 mg/100 g) as shown in Figure 1. With various treatments, the phenol concentrations continued to decrease gradually. Soaking had minimal effect compared to the control. However, with 3 h soaking the outer cover removed had a 50% phenolic reduction from the original concentration. Treatment with trona by boiling in 10% soda ash, outer coat removed, oven dried and milled showed even more reduction (72%) of phenolic compounds. The 48 h germination showed a very significant reduction ($P \leq 0.05$) in phenolic compounds content compared to all other treatments reaching 150 mg/100 gm equivalent to 82% reduction. After the 48 h. germination the phenolic compounds seemed to gradually start to increase again.

Proximate composition of products made from composite flours

The proximate composition of the products made from

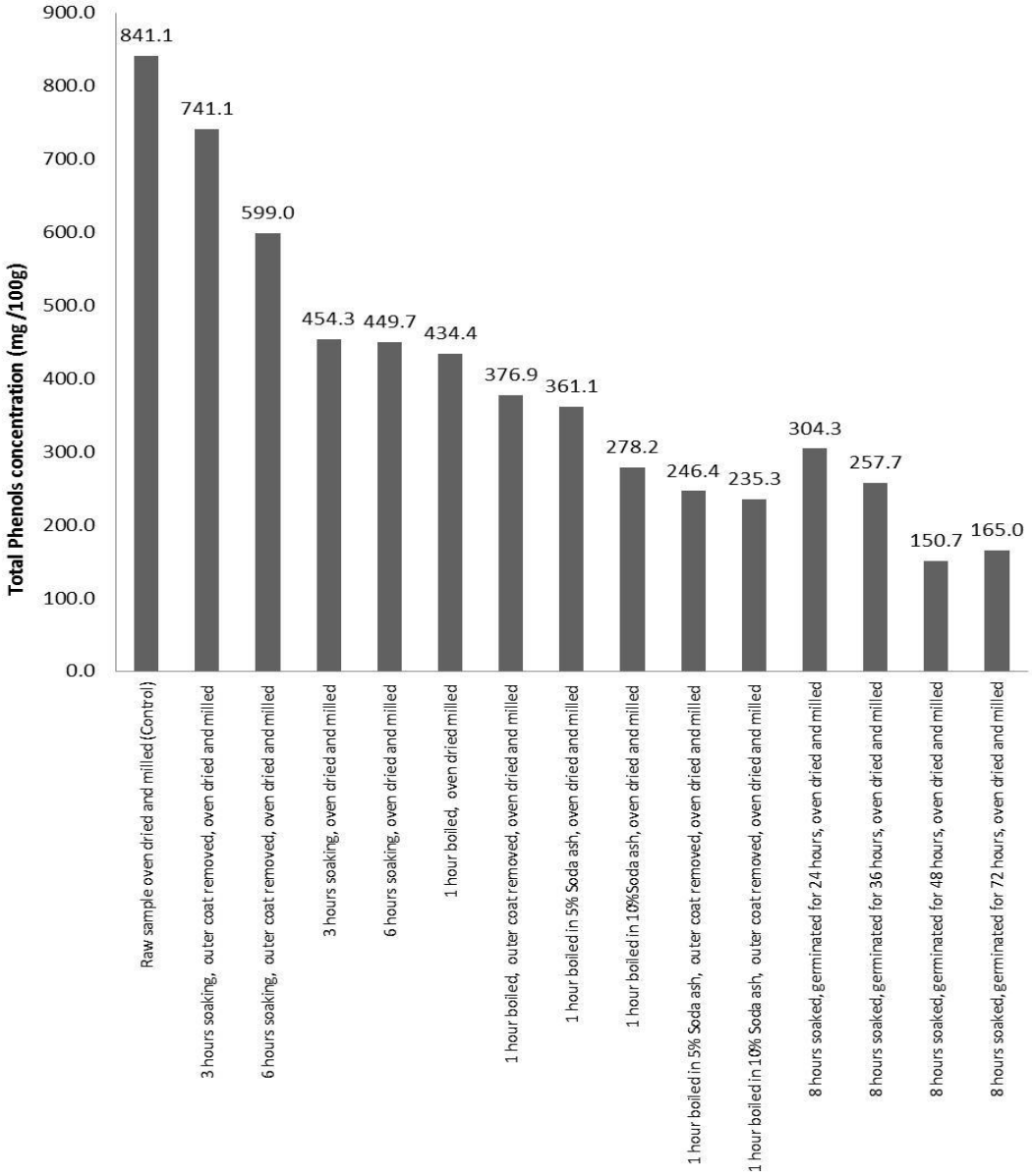

Figure 1. Phenolic compounds concentration for the various jack bean treatments.

composite flours from jack bean maize and wheat flour to prepare porridges, buns and breads are presented in Table 7. With regard to wheat flour and jack bean flour, they only had similar percent moisture, while the other proximate components differed significantly. The total phenols were significantly higher ($P \leq 0.05$) in jack beans compared to maize and wheat flour.

Sensory evaluation of products made from composite flours

Porridges JKPORRIDGE0595 and JKPORRIDGE 1585 were comparatively liked by the panellists, by giving an average higher score 'liked very much' in all organoleptic attributes (Table 8). There were no significant differences ($P \geq 0.05$) in all porridges with respect to flavour and smell except for porridge JKPORRDIGE 2575. All the panellists scored Porridge JKPORRDIGE 2575 the least but most of them gave the porridge an average score of 4 'neither like nor dislike in flavour taste and general acceptability and disliked slightly the colour of the porridge.

There were varying results with regards to breads prepared with composite flours. Bread JKBREAD 0595, JKBREAD 1090, and C were not significantly different ($P \geq 0.05$) in all sensory attributes except Bread JKBREAD 1585 with respect to general acceptability (Table 10). The panellists gave Bread JKBREAD 2080

Figure 2. Jack bean plant in the field at Mlingano Agricultural Research Institute, Tanzania.

Figure 3. Jack bean seeds

and JKBREAD 2575 an average score ranging from 3 to 5 i.e. ‘like moderately’, ‘like slightly, ‘neither like nor dislike’ and ’dislike slightly’. Bread JKBREAD 2575 was not appreciated by the panellists compared to the other breads since it was given an average score ranging 4 to 5 i.e. ‘Like slightly, ‘neither like nor dislike’ and ’dislike slightly’. In all three products prepared, there was no panellist who came back with any physiological discomfort or any other complaints of illness.

The panellists appreciated all the buns made from various combinations of the composite flours. The average score given ranged between 2 and 3 that is, ‘Like very much and like slightly’ (Table 9). There were no significant differences ($P \geq 0.05$) in all organoleptic properties. However, Buns JKBUNS 2575 were consistent in terms of decision by the panellists giving the

Table 7. Proximate composition, minerals and polyphenols for jack bean products (porridge, breads and buns).

S/N	Sample code[1]	Moisture %	Ash %	Fat %	Fibre %	Protein %	Calcium (mg)	Iron (mg)	Zinc (mg)	Total Phenols conc. (mg /100 g)
1	Wheat flour	10.9	0.5	0.8	12.2	9.0	653.2	23.2	16.7	65.2
2	Jack bean flour	4.5	4.3	1.8	22.8	26.4	9.1	3.9	1.82	148.9
3	Maize flour	12.6	0.4	2.7	8.7	0.2	175.1	13.2	3.5	61.4
4	JKPORRIDGE0595	87.9	0.1	1.7	10.8	0.0	217.7	13.8	7.1	23.1
5	JKPORRIDGE 1090	86.3	0.1	2.1	11.0	0.0	123.6	7.4	7.5	26.9
6	JKPORRIDGE 1585	87.3	0.0	5.0	11.5	0.0	140.2	9.2	6.7	40.9
7	JKPORRIDGE 2080	87.2	0.1	6.9	10.8	0.0	141.9	7.7	3.5	53.5
8	JKPORRDIGE 2575	88.0	0.1	8.6	10.8	0.0	152.2	12.8	8.6	106.9
9	JKBREAD 0595	34.1	0.7	1.6	10.2	0.8	143.9	2.8	0.9	38.0
10	JKBREAD 1090	32.8	1.7	2.5	10.1	1.0	136.2	2.7	0.7	44.6
11	JKBREAD 1585	33.7	1.2	2.5	10.3	0.8	138.4	4.6	0.9	75.3
12	JKBREAD 2080	34.5	1.3	4.2	10.3	1.9	161.5	5.3	0.7	111.1
13	JKBREAD 2575	33.6	1.8	4.5	11.2	1.8	174.3	4.7	0.7	120.8
14	JKBUNS 0595	35.5	0.5	1.2	8.8	1.9	211.7	6.9	5.1	18.5
15	JKBUNS 1090	36.4	0.9	2.1	8.6	4.1	155.5	8.5	5.7	56.2
16	JKBUNS 1585	34.4	1.1	2.9	8.3	3.0	165.5	8.0	6.4	77.8
17	JKBUNS 2080	37.6	0.9	3.2	9.6	3.2	196.0	9.5	6.6	91.1
18	JKBUNS 2575	40.4	1.4	3.7	9.7	2.9	207.0	13.1	6.7	120.6

[1]Check Table 2,3 and 4

Table 8. Composite flour porridge prepared using jack bean samples germinated at 48 h.

Sample Code*	Flavour	Taste	Smell	Colour	General acceptability
JKPORRIDGE0595	2.68 ± 0.90^{a}	2.68 ± 0.85^{a}	2.60 ± 1.15^{a}	2.72 ± 1.20^{ab}	2.56 ± 0.96^{a}
JKPORRIDGE 1090	3.08 ± 1.29^{a}	2.68 ± 1.18^{a}	3.08 ± 1.35^{ab}	2.52 ± 1.04^{ab}	2.92 ± 1.11^{ab}
JKPORRIDGE 1585	2.76 ± 1.13^{a}	2.64 ± 1.07^{a}	2.96 ± 1.20^{ab}	2.28 ± 1.13^{a}	$2.680.90\pm^{ab}$
JKPORRIDGE 2080	3.36 ± 1.32^{a}	3.44 ± 1.29^{a}	3.76 ± 1.42^{b}	3.28 ± 1.27^{b}	3.52 ± 1.50^{ab}
JKPORRDIGE 2575	4.40 ± 1.41^{b}	4.72 ± 1.59^{b}	5.04 ± 1.33^{c}	3.48 ± 1.47^{b}	4.04 ± 1.36^{c}

1=Like extremely, 2=Like very much 3= Like moderately, 4=Like slightly 5=Neither like nor dislike, 6=Dislike slightly, 7=Dislike most. Mean scores with the same superscripts are not significantly different (P≤0.05). *Check Table 2

buns a score of 3 ‘Like slightly’.

DISCUSSION

Proximate composition and minerals profile

The result of the proximate composition of the jack beans analyzed in our study has not shown much difference compared with those reported by other scientists. Ajewole, (2002) reported that, the moisture content was 9.2% while crude oil, crude protein, crude fibre and carbohydrate contents were 2.8, 28.6, 5.3 and 51.3%, respectively. Seena and Sridhar (2004) analyzed jack bean seeds, that consisted of 31.2%, 1.86%, 61.4% and 1580 kJ crude proteins, crude lipid, crude carbohydrates and energy, respectively.In other study done by (Sagarika et al.,1991) reported the proximate composition and nutritional quality of close variety of jack-bean *C. gladiate* (L.) to contain 29.2% crude proteins, 3.1% fat, 10.2% fibre and 53.2%;carbohydrates on dry matter basis, respectively.Similarly, Doss et al. (2011b) reported, crude protein level ranging from 29.8 to 32.2 % as well as crude lipid (3.1 to 6%), crude fibre (7.34 to 9.98%), ash content (3.56 to 5.93%) and Nitrogen free extracts ranging from 50.77 to 54.28%. Equally, Abitogun and Olasehinde, (2012) found moisture content to be 2.19 ± 0.32%, protein content 20.97 ± 0.51%, crude fibre 2.55 ±

Table 9. Composite flour breads prepared using jack bean samples germinated at 48 h.

Sample Code[ξ]	Flavour	Taste	Smell	Colour	General acceptability
JKBREAD 0595	2.21±1.34^{a}	1.82±1.19^{a}	2.00±1.53^{a}	1.95±1.10^{a}	1.95±1.55^{ab}
JKBREAD 1090	2.08±0.99^{a}	1.73±1.2^{a}	1.86±1.09^{a}	2.04±0.92^{a}	1.731±0.86^{a}
JKBREAD 1585	2.78±1.80^{ab}	2.73±1.5^{a}	3.00±1.44^{a}	2.52±1.53^{ab}	2.91±0.90^{b}
JKBREAD 2080	3.82±1.69^{bc}	4.13±1.57^{b}	5.08±1.34^{b}	3.47±1.70^{bc}	4.26±1.51^{c}
JKBREAD 2575	4.26±1.88^{c}	4.39±1.94^{b}	5.69±1.71^{b}	4.04±2.07^{c}	5.17±1.58^{c}

1=Like extremely, 2=Like very much 3= Like moderately, 4=Like slightly 5=Neither like nor dislike, 6=Dislike slightly, 7=Dislike most. Mean scores with the same superscripts are not significantly different (P≤0.05). [ξ]Check Table 3.

Table 10. Composite flour buns prepared using jackbean samples germinated at 48 h.

Sample Code[†]	Flavour	Taste	Smell	Colour	General Acceptability
JKBUNS 0595	2.69±1.39^{a}	2.36±1.35^{a}	2.97±1.31^{a}	2.86±1.62^{a}	2.55±1.38^{a}
JKBUNS 1090	2.80±1.36^{a}	2.88±1.44^{a}	2.94±1.24^{a}	2.61±1.35^{a}	2.72±1.20^{a}
JKBUNS 1585	2.58±1.42^{a}	2.91±1.66^{a}	2.97±1.38^{a}	2.38±1.17^{a}	2.83±1.40^{a}
JKBUNS 2080	2.55±1.20^{a}	2.97±1.64^{a}	3.11±1.48^{a}	2.61±1.15^{a}	3.00±1.58^{a}
JKBUNS 2575	3.30±1.84^{a}	3.19±1.76^{a}	3.33±1.80^{a}	3.33±1.95^{a}	3.36±1.72^{a}

1=Like extremely, 2=Like very much 3= Like moderately, 4=Like slightly 5=Neither like nor dislike, 6=Dislike slightly, 7=Dislike most. Mean scores with the same superscripts are not significantly different (P≤0.05. †Check Table 4.

0.15%, ash content 3.45 ± 0.96%, ether extract 10.23 ± 1.61% and carbohydrate levels 60.61 ± 2.51%. Most researchers have reported values that do not differ significantly.

Mineral content of the jack beans analysis showed some differences from the information published by other researchers elsewhere. The levels of calcium, iron and zinc for the jack bean seeds analyzed in our study gave, 8.99, 3.83 and 1.76 mg/100g, respectively. Akingbade et al. (2009) found significantly high levels of iron 7.31 mg/100g than what was obtained in this study, but comparatively lower than zinc levels (0.73 mg/100g). Ajewole, (2002) report significantly higher levels of calcium (177 mg/100g), same levels of zinc (1.76 mg/100g), but comparative iron levels (4.27 mg/100 g) was slightly higher than what was obtained in our study. Abitogun and Olasehinde, (2012) in a study on nutritional evaluation of seed and characterization of crude jack bean found levels of calcium, iron and zinc to be 3.21, 0.83 and 2.9 mg/100g, respectively. The differences might arise from the soil type and mineral content where the plants were cultivated; a lot of variability are seen in various locations.

Phenolic compounds

In this study the raw jack beans contained about 860 mg/100 g of phenolic compounds. These high levels of phenolic compounds were similar to those found by Seena and Sridhar (2004) who reported higher levels in jackbean seeds to the tune of 1420 mg/100 g total phenolics together with strong hemagglutination activity. In leguminosae family polyphenols are most commonly found in the cotyledons, and hence polyphenols have been found in dry bean (Phaseolus vulgaris L.), pea (Pisum sativum), chickpea (Cicer arietinum L.), faba bean (syn. broad bean, field bean; Vicia faba L.), cowpea (Vigna unguiculuta L.) and lentils (Lens culinuris L.) at varying levels (Salunkhe et al., 1982). Germination process especially at 48 h. seems to decrease effectively in the concentration of phenolic compounds. In this study, germination decreased in phenolic compounds by 82 % from the original content. Similar results of 82 % phenolic content (mgGAE/100g) reduction in germinated jack beans were reported by Chaturvedi et al. (2015) who suggested that, germination process was viable and suitable for processing method, and could be recommended for the utilization of these underutilized legume. It has been studied that during germination, a multitude of enzymes are produced to hydrolyze their respective substrates.

These include even the other anti-nutritional factors, which are present in jack beans. According to Babar (1988), the application of dry heat to seeds and meal was not effective in inactivating the trypsin inhibitor and reducing the polyphenol content. Soaking for 24 h followed by cooking for 20 min, was equally effective in destroying the TI activity. Germination of jack bean seeds for 40 h. decreased the levels of TI and polyphenols by 31 and 35%, respectively. Reddy et al. (1985) observed that, since phenolic compounds and tannins are water-soluble, they may be eliminated by decortication soaking or cooking. The findings by Bhagya et al. (2006)

suggested that, considerable decrease of anti-nutritional factors in cooked *Canavalia cathartica* pods qualifies for human or livestock consumption. Cracked jack bean seeds cooked (100°C) in trona ($NaCO_2.NaHCO_3.2H_2O$) solution for one hour proved to be more effective as a method for inactivating the anti-nutritional factors in jack bean seeds (Udedibie and Carlini, 1998).

According to Mamiro et al. (2010) Magadi soda is often added to traditional foods such as dry cereals or grain legumes for the purpose of shortening the cooking times, improving taste and flavor. However, Udedibie and Carlini (1998) reported that, Concanavalin A (Con A), the most studied of plant lectins, appeared to be the most important toxic and antinutritional factor in the seed, being highly resistant to heat treatments and to proteolytic digestion in the gut. It required 3 h of cooking at 96°C or 45 min of pressure cooking; 48 h of soaking in water prior to cooking for 2 h.; 72 h of soaking in water prior to ordinary cooking for 1 h or pressure-cooking for 15 min, to completely eliminate it from the seed. However, Udedibie and Carlini (1998) insists that complete inactivation of Con A in the seed can be easily achieved, if the seed is broken into pieces and cooked for 1h or pressure-cooked for 15 min in a process known as crack and cook. Crack and cook treatment shows a significant effect in reducing the undetectable levels in the concentration of various anti-nutritional factors (Udedibie and Carlini, 1998).

A personal narration of a farmer who grows jack beans as a cover crop in Muheza district in Tanzania during a workshop session at Mlingano Agricultural Research Institute revealed that; he tried to boil the jack beans the way he does for the normal beans; but when they ate with the family, they felt drowsiness and headache. He however did not stop there, he continued to research further where he decided to boil and discard the water two times. This time when they ate the beans they did not feel drowsiness as felt before. He said this is how he prepares and utilizes the jack beans he grows in his farm with his family as of now (Wilbard Kavishe: Personal comm.). Traditionally, African mothers in most ethnic tribes used to boil beans and discard the boiling water once or twice with a probable reason of removing the beany flavor and other components. This process is supported by the long soaking process in which the longer the soaking the more phenolics reduction. Similarly, (Udedibie et al., 1996) reported that, a two-stage cooking is a practice commonly used locally for preparing certain poisonous foodstuffs, such as jack beans and sword bean (*Canavalia gladiata*) seeds, for human consumption.

Acceptability studies

The products that were prepared for acceptability studies are jack beans flour samples germinated for 48 h. This is also assumed that, the other anti-nutritional factor will be hydrolyzed. The samples that were highly accepted were the buns, which were prepared by deep frying in oil. There was no significant difference ($P \geq 0.05$) with respect to all sensory attributes for the buns. This might be attributed to frying in oil as deep fried products which increases aroma and palatability. The other products i.e. porridge and breads, differed in some aspects. Since none of panelists came back with a report on any physiological discomfort or ill feeling, there is an indication that the 48 h. germination was possibly adequate in eliminating most of the anti-nutritional factors to a larger extent. This is probably one of the very few studies which have involved human subjects. However, Doss et al. (2011a) reports that mature beans are consumed by Indian tribal sects; Kurumba, Malayali, Irula and other Dravindian groups after cooking. According to Doss et al. (2011b), *C. ensiformis* ranks among the underutilized legumes that could ameliorate protein deficiency in human nutrition, particularly in developing countries.

Conclusion

The trials made on the acceptability of germinated jack-bean composite flours and the personal narration of the farmer shows, the possibility of the beans being used as a human food in the near future. Germination of the jack beans reduced to a greatest level the antinutritional factors embedded in the beans. The reports from researchers that jack beans are consumed by some ethnic groups like the tribal sects in India, if followed up and comprehend the way they do their preparation, will be a great stride towards utilization of jack beans.

Conflicts of Interests

The authors have not declared any conflicts of interests.

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