Proximate Composition and Phytonutrients of Heat Treated Loofah Gourd Luffa cylindrica (M J Roem) Seeds

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Abstract — Loofah gourd seeds (LGS) are often discarded after the removal the sponge due to the fact that they have little feed/food value occasioned by the high antinuutientt content. The effect of heat processing methods on the proximate composition and phytonutrients contents of loofah gourd seeds (LGS) was investigated using standard analytical procedure. Prior to the chemical analysis, dehulled loofah gourds seeds were boiled, cocked and toasted and the result of the chemical composition was compared with that of the raw loofah gourds seeds (RLGS) using analysis of variance procedure. Results revealed that the heat processing methods significantly ($P < 0.05$) reduced the ether extract, crude fibre, ash, gross energy, tannic acids, saponins, alkaloids, flavonoids, oxalate, phytin phosphorus and phytic acids of LGS, while the nitrogen free extract of LGS was significantly ($P < 0.05$) increased by the heat processing methods. The crude protein content of the seeds were 396.93, 390.03, 405.70 and 406.47 gKg-1, for RGLS, toasted (TLGS), boiled (BLGS) and cooked (CLGS) loofah gourd seeds respectively and the corresponding gross energy was 23.98, 23.16, 21.67 and 20.04 MJ/Kg respectively. Hence, the heat processing enhanced the nutritional potentials of LGS by increasing its nitrogen free extract and crude protein as well as reducing its crude fibre and phytonutrients. Cooking appears to give the best result and is hereby recommended as the best processing methods for LGS.

Index Terms — Boiling, Cooking, Loofah, Proximate, Phytonutrients, Seeds, Toasting.

1 Introduction

LOOFAH (Luffa cylindrica L.) is a plant commonly found in the tropics and sub-tropics and has been reported to have originated from India ([1], [2]). It is an herbaceous plant that thrives commonly with twinning tendrils [3]. The plant has a large succulent tendril climber with slender, slightly hairy furrowed stem and conspicuous leaves, which are attached alternatively to the stem. Loofah produces berry like fruit whose colour at tender stage is green with cucumber-like interior when immature, and yellow at puberty with a network of fibre surrounding large number of flat blackish seeds [3]. The fruit is harvested before puberty and eaten as vegetables in some part of Asia and Africa and serves as the source of the sponge when ripe containing at least 30 or more seeds [4].

The plant grows predominantly as weed in most parts of Nigeria. The matured fruits are used for domestic purposes as sponge. It is an excellent fruit in nature containing all the essential constituents required for good health of humans [5]. Its kernel contains between 45 – 51% oil which is composed of mainly oleic and linoleic acids. The seeds have laxative properties due to their high oil content. It contains a wide range of secondary metabolites with distinct biological activities. The seeds have been reported to be useful in the treatment of asthma, sinusitis and fever [6]. It is reported to possess antiviral, anti-tumor, antioxidant, anti-inflammatory and immunomodulatory activities [7].

The seeds being leguminous in nature are potentially rich in energy and protein. Its proximate analysis revealed that it can be used as a source of vegetable protein in human and animal diets ([8], [9]). The high fat content 33.46%-40% is suggestive of a high energy value ([9], [10]). However, there is dearth of information on the use of loofah gourd seeds in the diets of man and livestock.

One main criterion in the use of any material as food or feed is its nutrient composition. Also, the types of processing procedure feedstuff are subjected to also influence their nutrient profile and availability [11]. This study was therefore designed to determine the nutrient composition of loofah gourd seed subjected to three heat processing methods so as to confirm its potentials as a source of vegetable protein in livestock diets.

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2 Materials and Methods

2.1 Collection and Processing of Loofah Gourd Seed

Dried *Luffa cylindrica* (M J Roem) fruits were harvested from the wild growing plants along Ikorodu-Shagamu road when the gourds coat had turned leathery brown. Seeds were removed from the cucumber shaped fruits by breaking the leather colour coating on the gourd to expose the interior sponge. The interior sponge was vigorously agitated to release its black hard coated seed content. The seeds obtained from the sponge were soaked in fairly hot water at 60°C for 12 hours and thereafter dehulled by removing the black seed coat that had been softened by the soaking process. The dehulled seeds were then sundried and thereafter winnowed and cleaned to remove foreign materials. The seeds were divided into four parts for dry and wet heat processing namely cooking, boiling and toasting.

2.1.1 Cooked loofah gourd seed (CLGS)

Clean dried seeds were poured into already boiling water and left for 30 minutes to cook. The water was allowed to cover the seeds and the ratio of water to seeds was 5:1 by volume. The cooked seeds were poured into a sieve, allowed to drain properly and then sun dried for three days.

2.1.2 Boiled loofah gourd seed (BLGS)

Clean dried seeds were poured into a jute bag and immersed in hot boiling water and heated for 5 minutes when the water begins to boil again. The boiled seeds were then sun dried for three days.

2.1.3 Toasted loofah gourd seed (TLGS)

Clean dried seed were roasted for 30 minutes at 100 - 110°C in a gari fryer along with clean fine sand to prevent the seed from getting burnt and to ensure uniform distribution of heat. The seeds and sand mixture were continuously stirred throughout the toasting process using a wooden spatula. The toasted seeds were sieved out of the fine sand and allowed to cool.

2.1.4 Raw loofah gourd seed (RLGS)

Comprise dehulled clean seeds that were not exposed to any form of heat treatment.

The three differently processed seeds as well as the raw seeds were grinded using plate mill and packed in polyethylene sachets. Each of the test samples were replicated thrice, well labelled for proximate and phytonutrient analyses.

2.2 Determination of Proximate Composition and Gross Energy of Loofah Gourd Seeds

The moisture or dry matter was determined by drying 2g each of milled loofah gourd seed samples in an oven at 105°C until a constant weight was obtained for each sample. Crude protein was determined using Kjedahl method and crude fibre by Van Soest method as described by [12]. Two (2) grams each of the milled loofah gourd seed samples were weighed into extraction thimbles and the samples were defatted for 6 hours in a Soxhlet apparatus using petroleum ether at a boiling point range of 40 – 60°C for ether extract determination. The ash was determined by burning defatted sample in a muffle furnace at 600°C. The nitrogen free extract (NFE) was determined by difference. The gross energy was determined using IKA® WERKE Calorimeter system, C 2000 control high pressure bomb calorimeter.

2.3 Determination of Phytonutrients in Loofah Gourd Seeds

2.3.1 Tanin

200g of the milled sample was macerated into 10ml 70% aqueous solution of acetone and extracting for 2 hours at 30°C in a water bath with the aid of Gallenkamp orbital shaker at 120rpm to quantify the tannin content. Diethyl ether containing 1% acetic acid was used to extract the fats and the pigments in the sample. Tannin was then determined as total phenols in 0.05ml aliquot in test-tubes by the addition of distilled water to 1ml mark and the addition of 0.5ml Folin-Ciocalteau reagent (Sigma) and 2.5ml sodium carbonate. The absorbent of the solution was measured at 725nm after 40 minutes using the method of [13]. The tannin equivalent was calculated from the standard curve.

2.3.2 Phytin

Phytin-phosphorus was determined by soaking 8g of milled sample in 200ml of 2% HCl and allowed to stand for 3 hours. The extract was filtered through a double layer filter paper. 50ml of the sample filtrate was pipetted into 400ml beaker. 10ml of 0.3% ammonium thiocyanate was used as an indicator and 107ml of distilled water added to obtain acidity of pH 4.5. Ferrous chloride solution containing 0.00195g /ml of Fe was then titrated against the solution of the test samples until a brownish yellow colouration persisted for 5 minutes and the phytin content calculated by multiplying with a factor of 3.55 [14].

2.3.3 Oxalate, Total polyphenols, Saponin, Flavonoid and Alkaloid Concentration

Oxalate, total polyphenols, Saponin, Flavonoid and Alkaloids concentration were determined using the method outlined by [15], [16], [17], [18] and [19] respectively.

2.4 Statistical analysis

All data collected were analysed using analysis of variance. The means were separated using Duncan Multiple Range Test. All statistical analysis was done using the Assistat-Statistical Assistance 7.6 beta software developed by [20].

3 Results and Discussion

3.1 Proximate Composition and Gross Energy of Loofah Gourd Seeds

The result of proximate composition and gross energy of raw and processed loofah gourd seeds is as shown in Table 1. Different heat processing methods significantly ($P<0.05$) affected the proximate composition of loofah gourd seed meal (LGSM). The dry matter (DM) content of the heat processed loofah gourd seed meals were reduced by the treatment as compared with the raw seed meal except toasted loofah gourd seed meal (TLGSM) that had higher DM content. Toasted loofah gourd seed meal (TLGSM) had significantly ($P<0.05$) the highest (850gKg-1) DM content while cooked loofah gourd seed meal (CLGSM) had significantly ($P>0.05$) the lowest (810gKg-1) DM. Boiling and cooking are wet form of heat application and the water used serve as a medium in which some of the cell organic and inorganic matter dissolved, thereby lowering the dry matter content and consequently increasing the moisture. This finding agrees with [21] that boiling increases the moisture content of locust bean. Vadivel and Pugalenthi [22] and

Mubarak, [23] also reported increase in moisture content of dehulled Tamarind seeds and mung bean seeds respectively when exposed to different heat treatment. The lowered dry matter content observed in this experiment as a result of heat application indicates that wet form of heat can reduce the shelf life of the seeds because they could be predisposed to microbial attack. However, Dairo et al [23] reported that boiling and cooking did not have any significant effect on the dry matter content of loofah gourd seed.

The crude protein (CP) of the toasted loofah gourd seed was significantly reduced compared to the raw loofah gourd seed with cooked loofah gourd sees meal (CLGSM) having significantly (P<0.05) the highest (406gKg-1) that was statistically similar (405gKg-1) to boiled loofah gourd seed meal (P<0.05) while toasted loofah gourd seed meal (TLGSM) had significantly (P>0.05) the lowest (390gKg-1) CP. The low CP recorded in TLGSM could be due to the dry heat effect on the carbohydrate and protein in maillard reaction resulting in the production of brownish substance, hence may reduce the crude protein content. Cooking and boiling significantly increased the crude protein content of loofah gourd seeds as compared to the raw but were similar. Cooking and boiling may have caused some of the fat to be released into the hot water medium during processing thereby making the crude protein of the seeds to be relatively more concentrated as compared to raw and toasted loofah gourd seeds. De Almeida Costa et al [24] observed increase in the protein content and reduction in resistant starch for cooked legumes in comparison to the raw form. The findings in this study agreed with documented report of other workers that there is improved protein concentration when legumes were subjected to wet heat treatments ([22], [25], [26], [27], [28], [29], [30], [31]). Though the crude protein value obtained for the raw and heat processed loofah gourd seed was lower than the recorded content for soybean it still compared favourably with other legumes like cooked lima bean, boiled jack bean and boiled sword bean ([32]; [33]).

The fat content of LGSM was significantly reduced by the heat processing methods (P<0.05) RLGSM having significantly (P<0.05) the highest (304.43gKg-1) ether extract value which was not significantly (P>0.05) different from TLGSM (274.70gKg-1) and CLGSM having significantly (P<0.05) the lowest ether extract value. This could be as a result of volatilization of the fatty acids during toasting and diffusion into the water during boiling and cooking. This is contrary to the submission of Sotelo et al., [34] that boiling reduced the mineral content, increased the fat content of seeds, with no change in protein or fibre content. However, Mubarak [28] reported that cooking, autoclaving and microwave cooking treatments significantly decreased the fat content in mung bean seeds. Vadivel and Pugalenthi [22] also reported similar result for dehulled Tamarinds seed as a result of cooking. Nwaoguikpe et al., [31] documented similar report for boiled Mucuna pruriens seeds, while [30] indicated decreased fat content of boiled undecorticated castor oil seed which was attributed to solubilisation and leaching of oil in the water. All these mentioned reports agreed with the findings of this study.

The crude fibre and ash content of LGSM were lowered by heat processing method as compared with RLGSM. Crude fibre and ash contents of RLGSM was significantly (P<0.05) the highest (37.20, 55.47gKg-1 respectively) which were not statistically different (P>0.05) from BLGSM (36.20, 54.07gKg-1) and TLGSM (35.07, 53.33gKg-1) but significantly (P<0.05) higher than CLGSM (21.10 and 50.50gKg-1). This is an indication that the cooking method was very effective in reducing the crude fibre content of a typical legume seed. The reduction in the crude fibre of the treated LGSM could be due to softening of seed testa and/or the dissolution and subsequent gelatinization of soluble fibre such as pectins, gum and mucilage ([35], [36]). Cooking, boiling and dry application of heat were found to decrease crude fibre values of seeds ([23], [28], [29], [34], [37], [30]). Similarly, the ash content of cooked loofah gourd seed which is a representation of the inorganic matter (mineral) content of the seed was significantly (P<0.05) lower than other heat processed seeds. Though, the crude fibre and ash content of the cooked loofah gourd seeds were quite lower than others. The values 21.10gKg-1CF and 50.05gKg-1 ash content still compared favourably with what has been reported in literatures as 18.6 – 29.9gKg-1 CF and 20 – 50gKg-1 ash ([23], [38], [39]). This is an indication that the seeds could supply mineral elements that may be needed in the diet of animals. The reduction in the ash content of heat treated loofah gourd seeds could be attributed to the leaching of the mineral elements into the water and sublimation of volatile minerals as a result of toasting. This result agrees with the findings of [28], [22], [31], [30], [40] and [41]. These workers also attributed the dehulling effect of boiling treatment which must have predisposed the seeds to leaching of some of its mineral elements. Ogbonnaya et al., [21] indicated a slight reduction in the ash content of dawadawa as a result of boiling and subsequently soaking in water. However, Dairo et al [23] reported that boiling and cooking have no effect on the ash content of luffah gourd seed.

Nitrogen free extract (NFE) of loofah gourd seeds (LGSM) exposed to different heat processing methods significantly (P<0.05) differ from one another with CLGSM having significantly (P<0.05) the highest (191.03gKg-1) which was statistically similar (P>0.05) to BLGSM (135.86gKg-1) and RLGSM having significantly the lowest (46.47gKg-1). Heat processing has been reported to increase the nitrogen free extract (Soluble carbohydrate) of some leguminous seeds ([28], [22], [30], [42]).

There exist significant (P<0.05) difference in gross energy of unprocessed and heat processed loofah gourd seeds. However, the gross energy of heat processed loofah gourd seeds were statistically similar (P>0.05) and had the same trend as the ether extract. The gross energy content of the seeds decreased significantly (P<0.05) with heat processing probably due to the loss of some of the crude fat during processing, since fat produces twice as much energy as equal quantity of carbohydrate. This shows that the seed though concentrated in energy within the recommended energy dietary allowance for animals could be reduced by heat processing. However, the values obtained were higher when compared with those of some other legumes [43], vegetables [44] and cereals [45].

3.2 Phytonutrients of loofah gourd seeds

Table 2 shows some phytonutrients present in raw loofah gourd seed meal (RLGSM) and those subjected to different heat treatments. Heat processing significantly reduced the phytonutrients in loofah gourd seed. The phytonutrients of heat treated LGSMs were reduced significantly (P<0.05) by different heat processing methods when compared with RLGSM except polyphenol where BLGSM had significantly (P<0.05) the highest (0.35) value as compared to RLGSM (0.30). Tannin, saponins, phytin phosphorus and phytic acid had the same trend with RLGSM having significantly P<0.05) the highest values and TLGSM having significantly (P<0.05) the lowest values. Alkaloids and oxalate in the test samples followed the same statistical trend with RLGSM having significantly (P<0.05) highest (2.6, 3.2) values respectively while TLGSM recording significantly (P<0.05) the lowest (1.3, 2.4) values respectively. The reduction in the phytonutrients is expected as heat application has been reported as one of the means of reducing anti-nutritional factors (ANFs) in legumes ([46], [47], [48]). The result obtained in this study revealed that RLGSM contained phyto-nutrient in moderate quantity especially the oxalate, alkaloids, phytic acids, flavonoids and phytin phosphorus.

The amount of phytonutrients in LGSM was lower than what had been reported for most legumes. For example, the tannin content was lower than the values reported for mung bean seed and dehulled Tamarind seed ([22] and [28]), phytate for Bambara nut coat and flour [49], phenol for raw Mucuna pruriens seed [31] and phytic acid of Mucuna pruriens and Mucuna deeringiana [50]. The reduction in values of tannin, phytate and other phytonutrients in this study indicates that they are heat labile and the content of the respective phytonutrients are within tolerable limit by livestock as documented by other workers that reported similar results ([8], [22], [28], [31], [49], [51] and [52]). Phytate has been reported to decrease calcium bioavailability and forms calcium phytate complexes that inhibit the absorption of iron ([51], [53], [54]). Polyphenols are also reported to inhibit the activity of digestive as well as hydrolytic enzymes such as amylase, trypsin, chymotrypsin and lipase ([50], [55] and [56]). Tannins has been reported to form complexes with proteins and reduce their digestibility and palatability [57]. Therefore, its reduction by the heat processing will improve the nutritional quality of the loofah gourd seed. Toasting was found to have the profound reduction effect on all the phtyo-nutrients except flavonoids where cooking was most effective. So, toasting could be adopted as the most preferred means when detoxification of phytonutrients while processing LGSM.

4 Conclusion

The different thermal processing methods significantly influence the crude protein of LGSM, ether extract, crude fibre, nitrogen free extract and the cross energy of the seeds. The phytonutrients of LGSM were also reduced by the thermal processing method. Hence, the thermal process methods significantly enhance the nutritional values of LGSM.

Table 1: Proximate Composition (gKg-1) and Gross Energy of Raw and Processed Loofah Gourd Seeds.

Variables	Methods of processing				SEM
	Raw	Toasting	Boiling	Cooking	
Dry matter	840.5^{b}	850.73^{a}	832.83^{b}	810.20^{c}	6.47
Crude Protein	396.93^{b}	390.03^{c}	405.70^{a}	406.47^{a}	3.90
Ether Extract	304.43^{a}	274.70^{ab}	201.00^{bc}	141.10^{c}	36.86
Crude Fibre	37.20^{a}	35.07^{a}	36.20^{a}	21.10^{b}	3.79
Ash	55.47^{a}	53.33^{a}	54.07^{a}	50.50^{b}	1.05
Nitrogen Free Extract.	46.47^{b}	97.6^{b}	135.86^{ab}	191.03^{a}	30.53
Gross Energy (MJ/Kg)	23.98^{a}	23.16^{ab}	21.67^{ab}	20.04^{b}	0.87

abc → Means on the same row with different superscript differ significantly (P<0.05)

Table 2: Some Phytonutrients in Raw and Processed Loofah Gourd Seeds.

	Methods of Processing				SEM
	Raw	Cooking	Toasting	Boiling	
Tannic acid (%)	0.48a	0.39b	0.32c	0.41b	0.03
Polyphenol (%)	0.30b	0.28b	0.23c	0.35a	0.02
Saponins (%)	0.63a	0.48b	0.44c	0.52b	0.04
Alkaloids (%)	2.63a	1.36c	1.25c	2.04b	0.32
Flavonoids (%)	1.87a	1.44c	1.58b	1.67b	0.09
Oxalate (mg/g)	3.23a	2.56c	2.42c	2.93b	0.18
Phytin phosphorus (mg/g)	0.96a	0.74b	0.63c	0.82b	0.07
Phytic acid (mg/g)	3.41a	2.67b	2.24c	2.91b	0.24

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