

PROXIMATE AND AMINO ACID PROFILES OF SEED AND RIND OF THREE VARIETIES OF WATERMELON AND THEIR IMPLICATIONS FOR FISH NUTRITION

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ABSTRACT

Unconventional feedstuffs are increasingly gaining relevance in on-farm diet prepared for animals in a bid to reduce cost of feeding. This study therefore aimed to analyze the proximate composition and amino acid profile of agricultural by-products specifically the rinds and seeds, derived from three different varieties of watermelon (*Citrullus lanatus*). The ripe samples of the three varieties of watermelon (namely, sugarbaby, greybelle and kaolack) collected from a local grocery point were washed and cut open, after which their pulp was removed. The rinds and seeds were then collected per variety, and the sundried, milled and subsamples were analysed for proximate and amino acid profiles. The findings revealed that the seeds exhibited higher levels of crude protein and fat contents (ranging from 17.75–18.45% for protein and 14.42–15.73% for fat) compared to the rind, where levels ranged from 8.44–12.16% for protein and 2.96–3.50% for fat. The greybelle and kaolack varieties of *C. lanatus*, exhibited the highest protein content in their seeds, surpassing that of conventional feed ingredient like maize. This indicates that these watermelon seeds are notably rich in protein content. Similarly, the essential amino acid profile also differed among the varieties' by-products. The sugarbaby rind had the highest lysine content (5.25), while the lowest value (3.40) was found for the sugarbaby seeds. The methionine values of the kaolack seeds and sugarbaby rinds were greater (1.56 and 1.57, respectively) than those of their by-products. The levels of several of the essential amino acids recorded for the different varieties' by-products were found to be greater than those previously reported for maize. It was concluded that the watermelon by-products of the different varieties may be considered nutritional alternatives to maize in the diets of fin and shellfishes.

Keywords: Unconventional feed, watermelon, by-products, nutritional composition, fish nutrition.

INTRODUCTION

Nutrition is essential for the economic production of healthy, high-quality aquaculture products (Kuhn and Schwarz, 2017). The use of unconventional feedstuffs has recently been the focus of research in an attempt to find viable alternatives to expensive conventional feed ingredients. Reports of nutritional studies with most unconventional feedstuffs are promising, as they show good growth and better cost benefits (Okomoda *et al.*, 2022). Unconventional feedstuffs are not commonly sold in markets; hence, they are not traditional ingredients for commercial fish feed production (Musa *et al.*, 2021). These products are considered non-competitive in terms of human consumption, low cost, and composed of by-products or waste products from agriculture, farm-made feeds and processing industries (Abowei and

Ekubo, 2011). Hence, utilizing these discarded products in the diet of fish serves as a form of waste recycling/management, thereby enhancing good sanitation through their alternative use. One such discardable waste of agricultural origin is the watermelon (*Citrullus lanatus*) ring and seed.

C. lanatus is an important horticultural crop known for its sweet juicy fruit (Munisse *et al.*, 2011). The fruit pulp serves as a thirst quencher owing to its high-water content. It is widely distributed in the tropics, and different varieties are usually cultivated by different farmers based on consumer preferences and demands (Yamaguchi, 2006). When eaten fresh or processed to make juice, the rind and seeds generated as waste are often discarded (Asgher *et al.*, 2012). However, the seeds are highly nutritive and contain appreciable levels

of proteins, minerals and vitamins despite being an energy feed (Edwards *et al.*, 2003; Hall, 2004; Ahn *et al.*, 2011). The amino acid profile also has been reported to be higher than the standard recommended by the FAO according to Osuigwe (2007). While researchers have performed a great deal of work on the nutritional profile of *C. lanatus* seeds, there is still a paucity of information about the rind. As an unconventional ingredient with relatively high availability, nutritional quality is important for its potential as a viable alternative to replace conventional feedstuffs in the diet of fish (Abowei and Ekubo, 2011). Given that many varieties of *C. lanatus* are available nationwide, the nutritional qualities and profiles need to be examined and compared if they are to be utilized in animal nutrition. Hence, the aim of this study was to assess the proximate and amino acid profile of the by-products derived from three varieties of *C. lanatus* available in Makurdi, Benue State.

MATERIALS AND METHODS

Sample collection and preparation

Mature watermelon fruits were purchased from the Makurdi fruit market along the railway at high level in Benue State, Nigeria. Three varieties (sugarbaby, greybelle and kaolack) were obtained from the fruit market and taken to the Fish Nutrition Laboratory, Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University Makurdi. The fruits were sliced open using a clean stainless-steel knife. The seeds were separated from the pulp before separating the pulp from the rinds. The seeds were properly washed with clean water and allowed to drain in a clean tray. The rinds were chopped into tiny cubes and placed in separate trays. The whole set up was subsequently dried. The seeds and the rind were sundried, sorted to remove bad ones, ground with a laboratory blender, packed in an airtight container and stored in desiccators (containing silica gel) for further analysis.

Nutritional analysis of watermelon rind and seed samples

Nutritional analysis of the watermelon by-product samples was done in three replicates for each variety. The proximate analysis was carried out

according to AOAC (2006) while the amino acid profile was, however, determined using methods described by Benitez (1989). In brief, the sample was dried to constant weight, defatted, hydrolysed, evaporated in a rotary evaporator and loaded into an Applied Biosystems PTH amino acid analyser. An integrator attached to the Analyser then calculates the peak area proportional to the concentration of each of the amino acids obtained. All the analysis were carried out at Priority Laboratory Services, Zaria, Kaduna State.

Data analysis

The data analysis was carried out using GraphPad Prism 7[®]. Analysis of variance test was used to determine significant differences in the proximate and amino acid compositions among the three varieties by-products at the 5% level of significance, Duncan multiple range test was used as follow up test. A comparison between the amino acid profile of maize grains as reported in the literature (NRC 1984; 1994; 2008) and the current values was performed using a one sample t test as well.

RESULTS

The results of the proximate composition of the three varieties of watermelon seeds and rinds are presented in Table 1. The crude protein (CP) content of watermelon rinds varies among the three varieties of watermelon. The trend observed suggested that the crude protein and fat contents of the seeds were greater than those recorded for the rind (17.75–18.45% CP vs 8.44–12.16% CP and 14.42–15.73% fat vs 2.96–3.50% fat, respectively). The highest values of crude protein and fat were detected for the sugarbaby and greybelle varieties, respectively. In contrast, the ash and fibre contents were greater in the rind (13.16–13.61% for ash; 18.68–19.20%, for fibre) than in the seed (3.11–4.7%8; 14.29–15.55%, respectively) for all the varieties studied. However, moisture content was significantly greater in sugarbaby rinds (8.71%) and lowest in Kaolack seedlings (5.36%).

Table 1: Proximate composition of three varieties of watermelon seeds and rinds collected from Makurdi

Parameter	Sugarbaby Seed	Sugarbaby Rind	Greybelle Seed	Greybelle Rind	Kaolack Seed	Kaolack Rind	P value
Protein	17.75 ± 0.04 ^d	12.16 ± 0.14 ^c	18.06 ± 0.04 ^d	8.44 ± 0.11 ^a	18.45 ± 0.06 ^d	9.71 ± 0.30 ^b	0.001
Lipid	15.08 ± 0.07 ^d	2.96 ± 0.06 ^a	15.73 ± 0.12 ^e	3.50 ± 0.09 ^b	14.42 ± 0.13 ^c	3.12 ± 0.03 ^{ab}	0.001
Ash	3.46 ± 0.03 ^b	13.16 ± 0.04 ^d	4.78 ± 0.10 ^c	13.28 ± 0.03 ^d	3.11 ± 0.04 ^a	13.61 ± 0.03 ^e	0.006
Crude Fibre	14.29 ± 0.06 ^a	18.68 ± 0.10 ^c	15.11 ± 0.22 ^{ab}	18.94 ± 0.06 ^c	15.55 ± 0.16 ^b	19.20 ± 0.20 ^c	0.009
Moisture	7.50 ± 0.10 ^{bc}	8.71 ± 0.01 ^d	7.18 ± 0.04 ^b	7.32 ± 0.06 ^b	5.36 ± 0.10 ^a	7.90 ± 0.09 ^c	0.001
NFE	41.91 ± 0.07 ^b	44.32 ± 0.24 ^c	39.13 ± 0.35 ^a	48.52 ± 0.22 ^e	43.10 ± 0.09 ^b	46.45 ± 0.18 ^d	0.007

Means in the same row followed by different superscripts differ significantly (N = 3; p<0.05).

The amino acid profiles of watermelon rinds and seeds are presented in Tables 2 and 3. Generally, the various essential and nonessential amino acids differ in terms of the by-products of the different varieties. Hence, no trend could be established upon which one of the variety by-products could be assumed to be superior to the other. However, most of the time, the sugarbaby seed and the kaolack rinds had the lowest value of parameters recorded for essential amino acids, while the highest value of parameters was recorded for the sugarbaby ring. However, the greybelle and kaolack rinds had the lowest values for nonessential amino acids, while the Kaolack seed had the highest recorded value.

Table 2: Essential amino acid profiles of three varieties of watermelon seeds and rinds collected from Makurdi

Essential Amino Acid	Sugarbaby Seed	Sugarbaby Rind	Greybelle Seed	Greybelle Rind	Kaolack Seed	Kaolack Rind	P value
Leucine	5.80 ± 0.01 ^c	5.30 ± 0.01 ^b	5.99 ± 0.02 ^c	4.64 ± 0.00 ^a	6.00 ± 0.10 ^c	4.68 ± 0.01 ^a	0.001
Lysine	3.40 ± 0.02 ^a	5.25 ± 0.05 ^d	3.63 ± 0.02 ^b	5.00 ± 0.01 ^c	3.62 ± 0.01 ^b	5.03 ± 0.01 ^c	0.007
Isoleucine	3.42 ± 0.01 ^a	4.76 ± 0.06 ^d	3.55 ± 0.05 ^a	4.23 ± 0.01 ^c	3.85 ± 0.05 ^b	4.00 ± 0.01 ^b	0.002
Phenylalanine	3.80 ± 0.10 ^b	1.54 ± 0.04 ^a	4.19 ± 0.02 ^c	1.70 ± 0.10 ^a	4.54 ± 0.01 ^d	1.75 ± 0.01 ^a	0.007
Tryptophan	0.94 ± 0.02 ^b	1.08 ± 0.04 ^c	1.01 ± 0.01 ^{bc}	0.80 ± 0.01 ^a	1.06 ± 0.01 ^c	0.82 ± 0.01 ^a	0.002
Valine	3.88 ± 0.02 ^b	3.56 ± 0.04 ^a	4.11 ± 0.01 ^c	3.88 ± 0.02 ^b	4.22 ± 0.01 ^c	3.91 ± 0.02 ^b	0.001
Methionine	1.40 ± 0.01 ^a	1.57 ± 0.03 ^b	1.42 ± 0.03 ^a	1.30 ± 0.03 ^a	1.56 ± 0.01 ^b	1.35 ± 0.01 ^a	0.004
Arginine	8.98 ± 0.03 ^a	10.45 ± 0.05 ^c	10.68 ± 0.01 ^d	9.83 ± 0.02 ^b	11.75 ± 0.05 ^e	8.96 ± 0.01 ^a	0.009
Histidine	2.40 ± 0.10 ^{ab}	2.40 ± 0.03 ^b	2.50 ± 0.01 ^b	2.15 ± 0.01 ^a	2.59 ± 0.03 ^b	2.44 ± 0.01 ^b	0.005
Threonine	3.05 ± 0.02 ^c	1.56 ± 0.01 ^b	3.14 ± 0.00 ^d	1.21 ± 0.02 ^a	3.41 ± 0.02 ^e	1.25 ± 0.00 ^a	0.001

Means in the same row followed by different superscripts differ significantly (N = 3; p<0.05).

Table 3: Nonessential amino acids in three varieties of watermelon seed and Rind collected from Makurdi.

NonEssential Amino Acid	Sugarbaby Seed	Sugarbaby Rind	Greybelle Seed	Greybelle Rind	Kaolack Seed	Kaolack Rind	P value
Proline	2.77 ± 0.03 ^c	1.33 ± 0.01 ^b	2.93 ± 0.01 ^d	1.10 ± 0.02 ^a	3.06 ± 0.01 ^e	1.13 ± 0.01 ^a	0.002
Tyrosine	3.41 ± 0.03 ^c	3.48 ± 0.04 ^c	3.63 ± 0.02 ^d	2.58 ± 0.00 ^a	3.81 ± 0.02 ^e	2.76 ± 0.00 ^b	0.009
Cystine	1.03 ± 0.00 ^b	0.99 ± 0.02 ^b	1.16 ± 0.01 ^c	0.81 ± 0.03 ^a	1.23 ± 0.01 ^c	0.86 ± 0.01 ^a	0.001
Alanine	4.15 ± 0.05 ^a	6.50 ± 0.10 ^c	4.62 ± 0.03 ^b	6.13 ± 0.02 ^c	4.50 ± 0.10 ^{ab}	6.40 ± 0.10 ^c	0.001
Glutamic acid	15.65 ± 0.05 ^d	14.57 ± 0.03 ^c	16.36 ± 0.01 ^e	14.23 ± 0.00 ^b	16.8 ± 0.01 ^f	13.64 ± 0.01 ^a	0.009
Glycine	3.00 ± 0.10 ^a	6.36 ± 0.04 ^c	3.04 ± 0.02 ^a	5.66 ± 0.01 ^b	3.22 ± 0.01 ^a	5.72 ± 0.00 ^b	0.005
Serine	3.22 ± 0.01 ^c	2.35 ± 0.05 ^b	3.44 ± 0.00 ^d	2.17 ± 0.01 ^a	3.35 ± 0.05 ^{cd}	2.25 ± 0.01 ^{ab}	0.001
Aspartic acid	8.32 ± 0.01 ^d	7.34 ± 0.01 ^c	8.55 ± 0.05 ^e	6.77 ± 0.01 ^b	8.71 ± 0.03 ^f	6.60 ± 0.03 ^a	0.007

Means in the same row followed by different superscripts differ significantly (N = 3; p<0.05).

Figure 1-12 shows the essential and nonessential amino acid profiles of watermelon rinds and seeds in comparison with those of maize, which is often used as an energy source in the feed of aquaculture species. The results obtained showed that the concentrations of some of the essential amino acids recorded for the different varieties' by-products were greater than those previously reported by NRC (1984; 1994; 2008) for the conventional ingredient maize. These include mainly arginine, isoleucine, and lysine, which are essential amino acids (Figures 1 – 6). However, for aspartic acid and, in some cases, glycine, the content was greater than that in maize meal (Figures 7–12). There were fewer other amino acids than previously reported for maize.

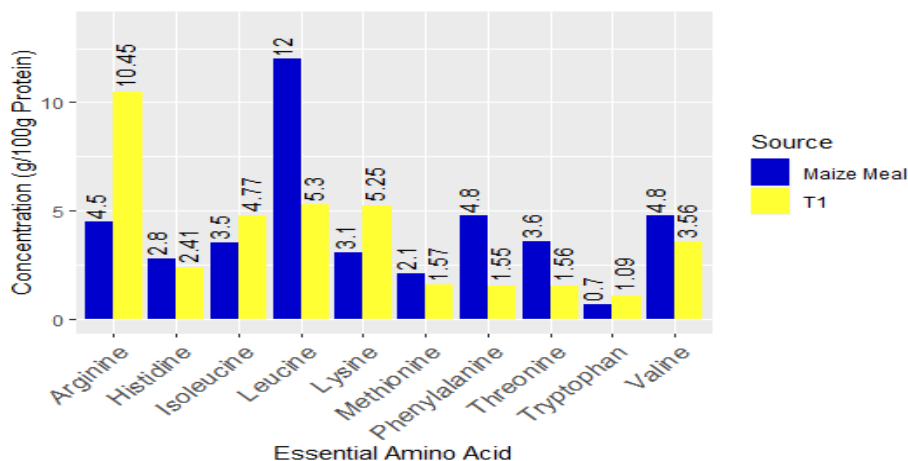


Figure 1: Essential amino acids in T1 (Sugarbaby rind) and maize grain (NRC 1984; 1994; 2008).

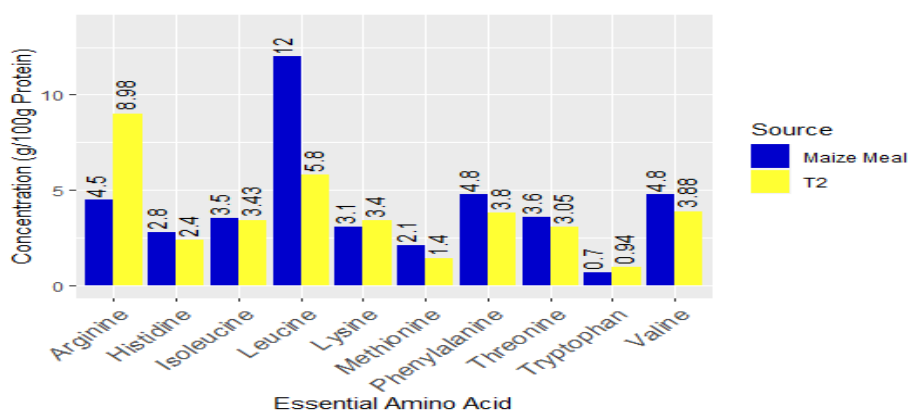


Figure 2: Essential amino acids in T2 (Sugarbaby seed) and maize grain (NRC 1984; 1994; 2008).

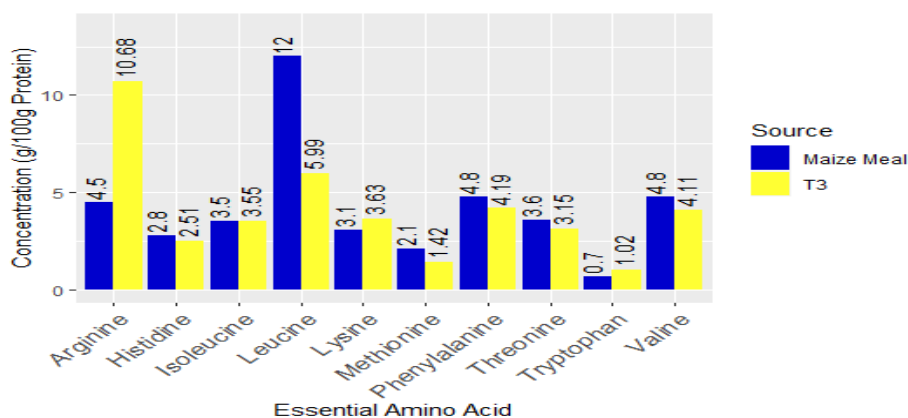


Figure 3: Essential amino acids in T3 (Greybelle) and maize grain (NRC 1984; 1994; 2008).

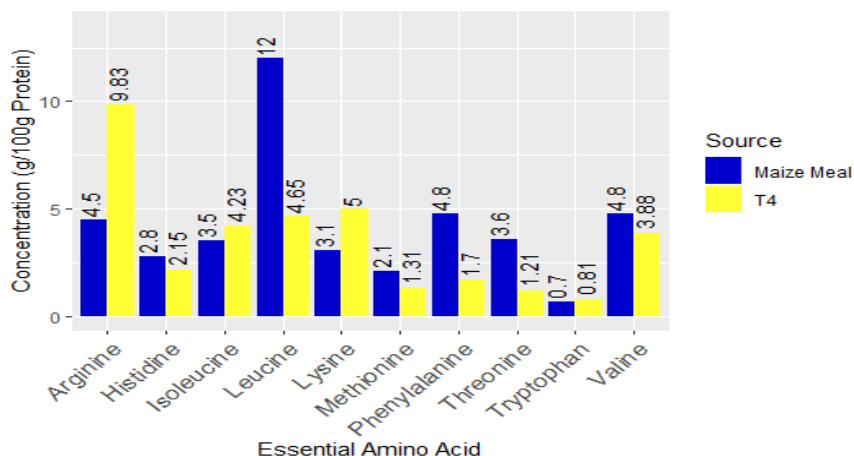


Figure 4: Essential amino acids in T4 (Greybelle) and maize grain (NRC 1984; 1994; 2008).

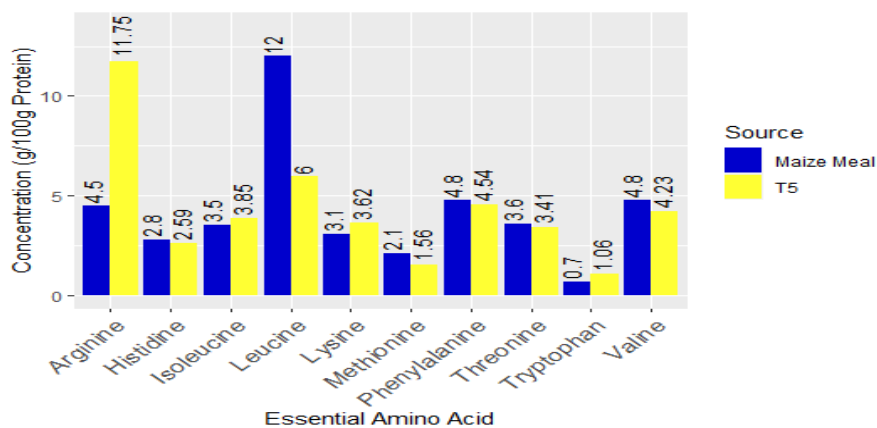


Figure 5: Essential amino acids in T5 (Kaolack seed) and maize grain (NRC 1984; 1994; 2008).

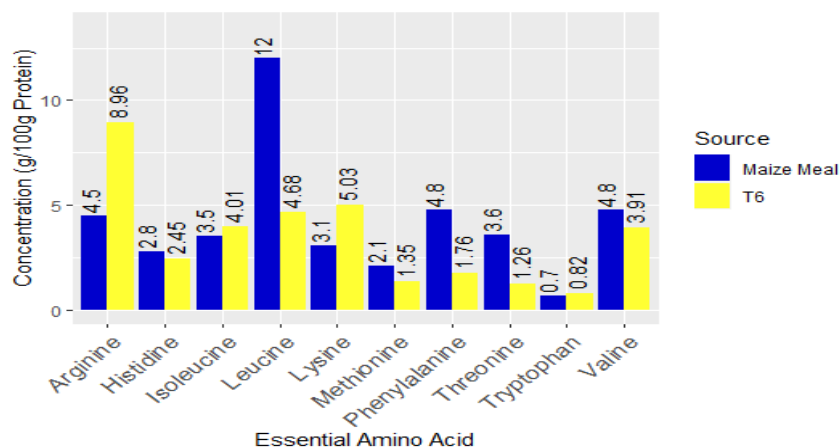


Figure 6: Essential amino acids in T6 (Kaolack rind) and maize grain (NRC 1984; 1994; 2008).

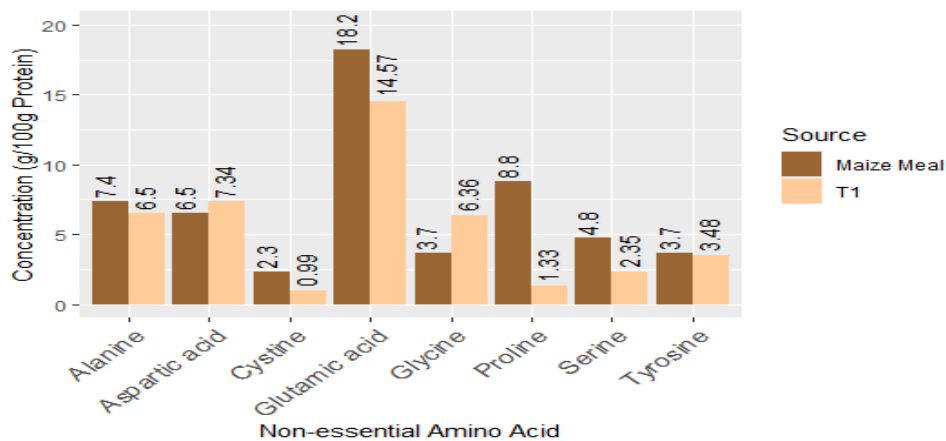


Figure 7: Nonessential amino acids in T1 (sugarbaby rind) and maize grain (NRC 1984; 1994; 2008).

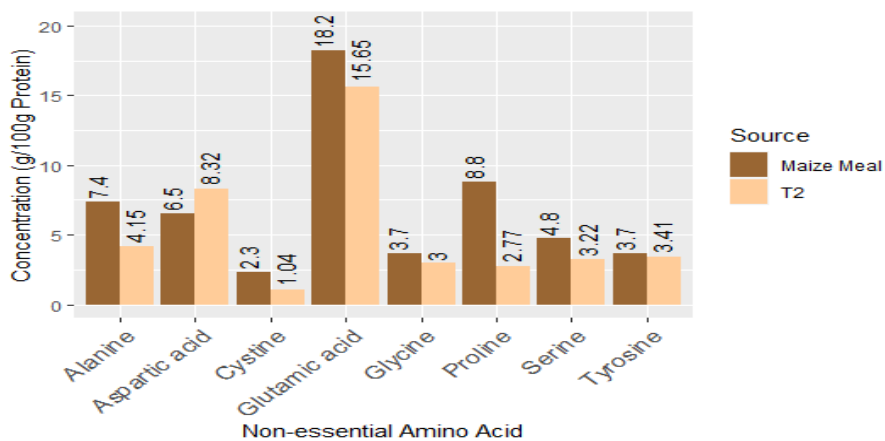


Figure 8: Nonessential amino acids in T2 (sugarbaby seed) and maize grain (NRC 1984; 1994; 2008).

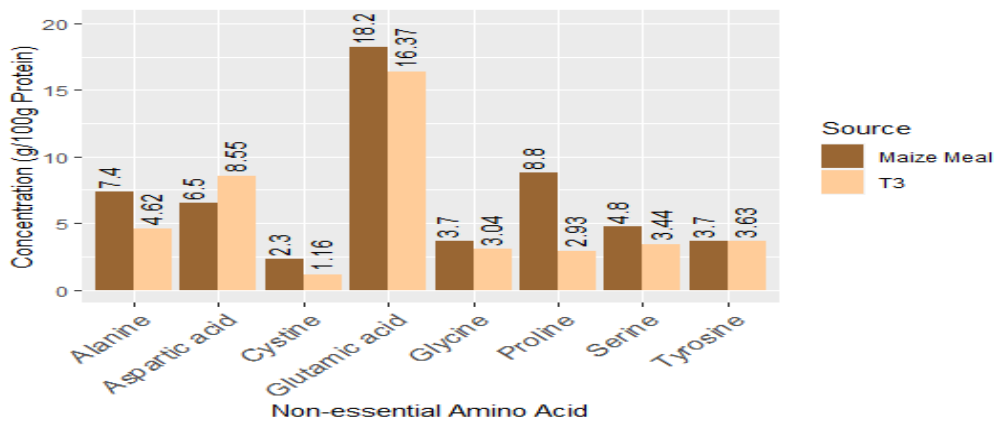


Figure 9: Nonessential amino acids in T3 (Greybelle seed) and maize grain (NRC 1984; 1994; 2008).

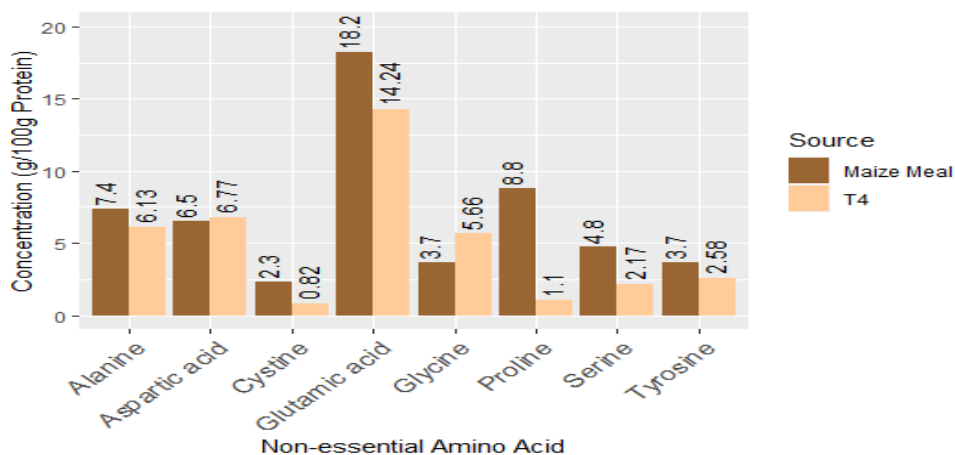


Figure 10: Nonessential amino acids in T4 (Greybelle rind) and maize grains (NRC 1984; 1994; 2008).

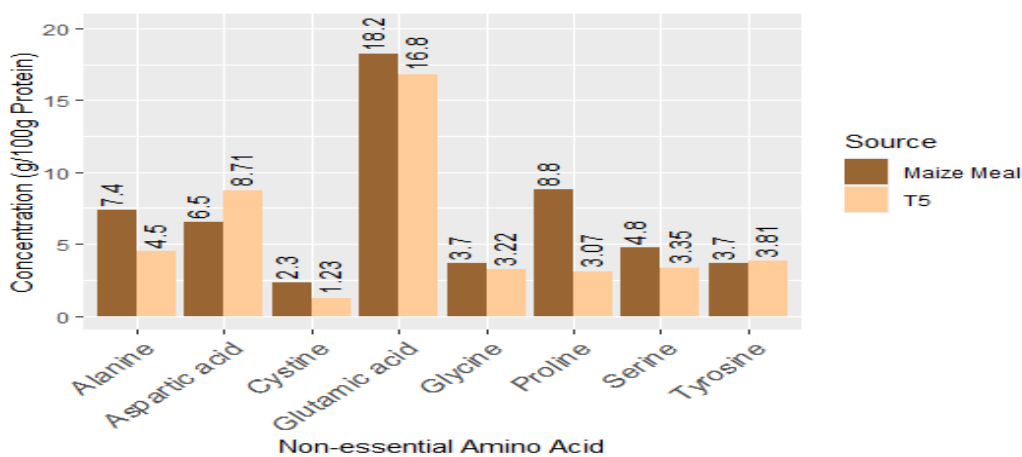


Figure 11: Nonessential amino acids in T5 (Kaolack seed) and maize grain (NRC 1984; 1994; 2008).

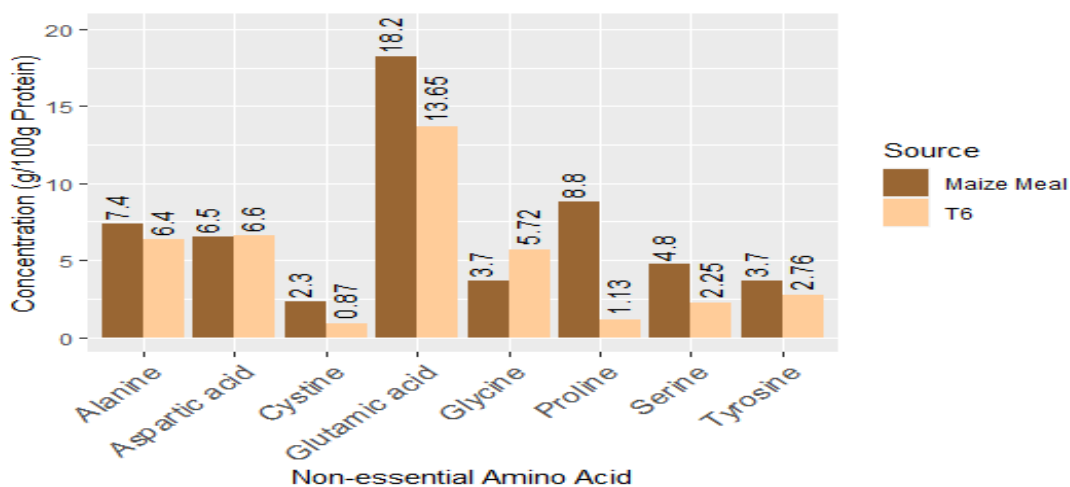


Figure 12: Nonessential amino acids in T6 (Kaolack rind) and maize grain (NRC 1984; 1994; 2008).

DISCUSSION

The nutritional profile of unconventional feedstuffs is a dependable index for their utilization as alternative feed ingredients in the nutrition of animals (Okomoda *et al.*, 2018). With the increase in *C. lanatus* farming resulting from the increased demand for its juice (Rahman *et al.*, 2015), the availability of feed ingredients for use in diet composition should not be a problem. The proximate compositions of the seeds and rinds of the sugarbaby, greybelle and kaolack varieties of *Citrullus lanatus* indicated better crude protein and fat contents in the seed than the rind. This finding agrees with the results of Sadiq *et al.* (2018), who reported higher crude protein values in the seeds than in the pulp and peels of a single variety of *C. lanatus*. Similarly, Milala *et al.* (2018) recorded higher crude protein values in both processed and unprocessed seeds of *C. lanatus*. According to Williams and Lenkat (2018), proteins have unique functional properties and are important for biological functions and cell structure. The crude protein values of *C. lanatus* are consistent with the results of Rahman *et al.* (2015; 2018) for maize; hence, the seeds of all the *C. lanatus* varieties, despite being an energy source, are appreciable sources of rich protein. Fat/ether extract is a vital component of any feed ingredient since it provides animals with a tremendous energy supply (Jacob *et al.*, 2015). The amount of ether extract obtained from *C. lanatus* was greater for the seeds than for the rinds for all three varieties, suggesting that the seeds contained more oil than the rinds. These results are in line with the findings of Amoo *et al.* (2004) on *Cucurbita maxima* seeds. However, Gav *et al.* (2019) recorded slightly lower values of ether extract in *C. lanatus* seeds in Makurdi. The high value of the ether extract in *C. lanatus* seeds may be indicative of it being an oil seed.

According to Omotoso (2006), the proportion of ash reflects the minerals present in a feed ingredient. Hence, samples with a high percentage of ash are expected to assist peristaltic movement as well as speed up metabolic processes necessary for improving the growth and development of the organism (Bello *et al.* 2008). The ash content of *C. lanatus* was significantly greater in the rind than in the seeds of the three varieties of *C. lanatus*. The higher ash content of the rinds agreed with the observations of Olalekan and Boseda (2010) on the

rind of jackbean and the work of Gav *et al.* (2019) on *C. lanatus*. Similarly, the crude fibre content was greater in the rind than in the seed for all the varieties of *C. lanatus* assessed. This result is in accordance with the findings of Omoniyi (2020), who also reported low ash values for watermelon seeds. Crude fibre consists of cellulose, hemicelluloses and lignin (Jacob *et al.* 2015). High percentages of fibre help accelerate metabolic processes; however, at high values, they tend to lower the metabolizable energy and digestibility of such feedstuffs (Atasie *et al.*, 2009). There was more crude fibre in rinds than seeds of *C. lanatus* in this study, and this is consistent with the reported of Gav *et al.* (2019). The moisture content of any food material is a measure of the life span of the food (Ozioma *et al.*, 2013). It indicates how long a food material can be stored without becoming mouldy (Fellow, 2000). The moisture content of the seeds was lower than that of the rind for the three varieties of watermelon. These observations correspond with previous works by Milala *et al.* (2018), Otutu *et al.* (2015), and Rekha and Rose (2016).

The amino acid profiles of the three varieties of *C. lanatus* (sugarbaby, greybelle and kaolack) showed that the seeds and rinds contained all ten essential amino acids at various quantities. The same results were obtained for nonessential amino acids, which were also recorded in the present study. Ali (2006), Taiwo *et al.* (2008) and Umar and Shuaibu (2013) reported similar amino acids, with lower values obtained for their different unconventional feed ingredients. Our observations revealed that the arginine, isoleucine, and lysine levels were greater in *C. lanatus* than in maize, similar to the findings for aspartic acid, a nonessential amino acid. This finding suggested that *C. lanatus* may supply these amino acids better than maize when fed to fish; hence, nutritional trials are needed to elucidate the effect of their inclusion in the fish diet. In addition, there were other amino acids, which also compared well with the values for maize, suggesting that these amino acids could provide for the needs of the fish just as the conventional ingredient maize.

CONCLUSION

The watermelon rinds and seeds are seen to be good sources of protein, fat and essential amino acids. Therefore, these materials provide viable substitutes for conventional feeds such as maize;

however, this possibility is subject to confirmation through well-designed nutritional studies. Hence, the preliminary findings of this study need to be validated through feeding trials to determine the nutritional utilization of varieties of *C. lanatus* by-products in the diets of different fins and shellfishes. This approach will help develop nutritionally high least-cost feed without compromising the growth performance or health status of the fed fin or shellfish.

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