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Research Article

Chemical Analysis of Kuli Kuli (Fried Groundnut Cake) Sold in Some Selected Markets in Maiduguri, Borno State, Nigeria

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Abstract

This study was carried out in order to determine the chemical composition of kuli kuli, a kind of local snack, sold in some Maiduguri markets namely: Monday, Custom, Tashan Baga, Ngomari and Buluntkutu markets. The chemical analyses conducted include proximate composition (moisture, protein, fat, fibre, ash and carbohydrate), as well as amino acid profile and mineral contents; using the standard methods of analysis. Results of the proximate composition indicate a significant difference ($p \leq 0.05$) between all the components quantified. The percent proximate composition ranged from 1.32± 0.02 to 4.16± 0.03, 30.32± 0.01 to 42.58± 0.06, 24.90± 0.04 to 32.68± 0.02, 2.46± 0.02 to 9.25± 0.24, and 11.45± 0.05 to 23.56± 0.06, for moisture, protein, fat, ash and carbohydrate, respectively. The essential amino acid contents, expressed in mg/100g, of all the samples analyzed, also varied significantly ($p \leq 0.05$) except in the lysine and histidine contents. The values ranged from 6.68± 0.36 to 7.94± 0.06, 0.71± 0.17 to 1.15± 0.05, and 3.63± 0.12 to 5.04± 0.05, for leucine, tryptophan and lysine, respectively. The essential amino acid contents in the kulikuli were found in

the decreasing order of Leucine > Arginine > Lysine > Phenylalanine > Threonine > Isoleucine > Valine > Histidine > Methionine > Tryptophan The non-essential amino acid contents (expressed in mg/100g), varied significantly (p≤0.05) too. Glutamic acid was observed to be the most abundant amino acid in all the *kuli kuli* samples and it ranged from 13.23± 0.21 to 14.72± 0.03, whereas cysteine which was the least in concentration ranged from 0.7± 0.01 to 1.38± 0.05 mg/100g. The non-essential amino acid contents were also found in descending order of glutamic acid > aspartic acid > glycine > alanine > proline > serine > tyrosine > cystiene On the other hand, the values obtained for the fiber contents varied significantly (p≤0.05) among the samples, and it ranged from 5.11± 0.02 to 10.61± 0.05%. The concentration of minerals (expressed in mg/100g) varied significantly (p≤0.05), with potassium and iron being the most and least recorded values, ranging from 20.50± 0.01 to 83.00± 0.12 and 1.00± 0.01 to 4.00± 0.01, respectively. It was concluded that *kuli kuli* could be commercially produced as a high density nutrient product.

Introduction

Kuli kuli is a groundnut bar snack that is usually produced during groundnut oil extraction in West African Countries [1]. It is obtained after the oil in the groundnut cake is extracted, molded and deep-fried in fat or vegetable oil; with or without the addition of ingredients such as salt, sugar and pepper. *Kuli kuli* is mostly consumed by especially the young children as a snack and indirectly, by all age groups in the society as *yajin kuli kuli* [1]. *Kulikuli* is also used as an ingredient in preparing weaning foods and a spice known as "*yajin kuli kuli*". The latter is further used as an ingredient in processing such meat products as suya, balangu and kilishi [3,4]. Yajin *kuli kuli* is also consumed along with other local foods like *dan wake*, salads, *masa, akara* and numerous other fried or roasted food items.

The production and selling of *kuli kuli* have been observed to provide a meaningful revenue to women in both rural and urban centers in Borno State, including, Maiduguri. *Kuli kuli* is usually sold at the markets by women and children sitting at strategic locations with the products piled or stacked on trays or in basins with or without covers; the products are sometimes sold in transparent knotted polythene bags. *Kuli kuli* is also hawked along major roads, motor parks and other public places such as hospitals and school premises. Studies indicate that *kuli kuli* may be very rich in nutrients such as proteins, fats and minerals just like its parent material - groundnut [5,6]. These studies have largely focused on the proximate and mineral compositions of *kuli kuli*. The present study is therefore designed to investigate the samples of kuli kuli from selected markets in Maiduguri, with the aim of assessing their proximate composition, the amino profiles of the protein contents, and the mineral compositions.

Materials and Methods

Sample Collection

A completely randomized factorial design was used in the collection of kuli kuli [7]. A 1×5×2 factorial design was deployed, where 1 represents kuli kuli, 5 represents the selected five markets in Maiduguri, namely: Monday, Custom, Tashan Baga, Ngomari and Bulunkutu markets, while 2 represents the number

of *kuli kuli* samples collected from each of the five markets. A large quantity of *kuli kuli* was obtained from each of the markets, pooled and two samples of 1kg each were taken from the pool and packaged in previously tagged and sterile plastic containers with lids. A total number of 10 samples of *kuli kuli* were analysed. The samples were ground using a clean wooden mortar and pestle in order to reduce the size for all the subsequent analyses.

Proximate Analysis

The chemical composition (moisture, crude protein, crude fat, ash and fibre) of the *kuli kuli* samples were determined using the methods described in AOAC, 2006 [8] and Nelson, 2019 [9], whereas the carbohydrate content was determined by difference, that is subtracting the sum of the percentages of other constituents - moisture, crude fibre, protein, fat and ash obtained, from 100.

Determination of Amino Acid Profile

The amino acid profile of the *kuli kuli* samples were determined using the methods described by Adam et al., 2020.

Mineral Analysis

The following minerals: zinc, potassium, iron, sodium, calcium, phosphorus and copper were determined due to their importance in the body. The mineral contents of kuli kuli were quantified following the procedures described by Nelson, 2019 [9].

Statistical Analysis

The data generated was subjected to analysis of variance (ANOVA) as described in Dean et al., 2017 [7], and where differences exist, means were separated using Duncan Multiple Range Test at 5% level of significance [7].

Results and Discussion

Proximate Composition of the Kuli kuli Samples

Snack, which contains essential nutrients, such as proteins, fats, carbohydrates, vitamins and minerals, is the most indispensable part of diet for both the adults and children. The percentage proximate composition of *kuli kuli* samples investigated in this study, are presented in Table 1. A significant difference ($p \geq 0.05$) was observed between all the parameters (moisture, crude protein, crude fat, fiber, ash and carbohydrate) quantified. The percentage moisture of the *kuli kuli* samples ranged from 1.32± 0.02 in *kuli kuli* from Monday Market (MM1) to 4.16± 0.03 in *kuli kuli* from Ngomari Market (NM1). The level of moisture recorded in this study is lower than the values reported by Emelike and Akusu (2018) [10] in similar *kuli kuli* samples which ranged from 6.31 to 6.9%. The crude protein content recorded was higher than all other parameters evaluated. The highest values of crude protein, 42.58± 0.06, recorded was in *kuli kuli* from Ngomari Market

(NM2), while the lowest value recorded, 30.32± 0.01, was in *kuli kuli* from Monday Market (MM1). These values are also higher than those reported by Ezekiel et al. (2011) [1] and Emilike and Akusu (2018) [10], which are 39.7% and 30.88%, respectively. The variations in the crude protein contents, and indeed, in many other components, may be attributed to the differences in the varieties of groundnut used in the preparation of the *kuli kuli* in one hand, and the variations in the processing techniques applied by the individual processors, in the other hand. Furthermore, the percent crude fat contents of the *kuli kuli* samples ranged from the lowest value of 24.90± 0.04 to the highest value of 31.95± 0.01 in samples from Bulunkutu (BM2) and Ngomari (NM1) markets, respectively. Ezekiel et al. (2011) [1] and Emilike and Akusu (2018) [10], also reported high values of crude fat in *kuli kuli*, up to 30.30% and 24.60%, respectively. In another study, Oko et al. (2015) [11] however, recorded a lower value of 16.00%. The high contents of crude fat in the *kuli kuli* samples may be attributed to the fact that groundnut, which is the major raw material in *kuli kuli* preparation, is naturally high in fat content.

Similarly, the fibre content was observed to be highest in kuli kuli from Custom market (CM2); the highest value recorded was 10.61± 0.05% in samples from the Custom market while the lowest value, 6.16± 0.02%, was obtained from samples from Monday market (MM1). These values were also higher than the values reported by other researchers including Oko et al. (2015) [11], and Emelike and Akusu (2018) [10], which were 0.25% and 1.32%, respectively. Batal et al. (2005) [8], however reported values ranging from 5.77 to 11.00% in a study they conducted on solvent extracted groundnut cakes. This shows that kuli kuli could serve as a good source of fibre in the diet. The ash content of the samples ranged from 3.80± 0.01 to 9.25± 0.24 in kuli kuli from Custom (CM1) and Ngomari (NM2) markets, respectively (Table 1). These values are also higher than those reported by Ezekiel et al. (2011) [1] and Emelike and Akusu (2018) [10], which were 2.88% and 4.63%, respectively. This implies that kuli kuli samples investigated in this study may contain high amounts of minerals. As for the carbohydrate contents, the values ranged from the lowest of 11.45± 0.05 to the highest of 23.56± 0.06 in samples from Tashan Baga (TBM1) and Ngomari (NM2) markets, respectively. These values are less than those obtained by Emelike and Akusu (2018) [10], who recorded carbohydrate contents higher than 52% in kuli kuli samples. This result implies that kuli kuli could be produced as a high density nutrient product; and that regular consumption of kuli kuli could contribute significantly in meeting the daily mineral requirements of the consumers.

Table 1: *Proximate Composition (%) of Kulikuli Sold in Selected Maiduguri Markets1*

Sample Code[3]	Parameters2					
	Moisture	**Protein**	**Fat**	**Fiber**	**Ash**	**Carbohydrate**
MM1	1.32± 0.02^{b}	30.32± 0.01^{a}	31.54± 0.02^{i}	6.16± 0.02^{b}	3.71± 0.04^{b}	26.87± 0.05^{k}
MM2	2.60± 0.05^{e}	38.31± 0.03^{h}	29.66± 0.04^{f}	7.21± 0.02^{cd}	6.06± 0.03^{f}	16.29± 0.05^{c}
CM1	1.82± 0.00^{ad}	35.32± 0.02^{d}	30.65± 0.05^{h}	6.17± 0.15^{b}	4.17± 0.02^{c}	22.04± 0.03^{i}
CM2	2.52± 0.02^{e}	33.78± 0.01^{b}	26.59± 0.05^{b}	10.58± 0.02^{g}	7.14± 0.02^{f}	19.38± 0.01^{e}
TBM1	2.65± 0.03^{a}	37.81± 0.02^{g}	27.20± 0.03^{c}	7.08± 0.03^{c}	3.80± 0.01^{b}	23.56± 0.03^{j}
TBM2	1.82± 0.06^{ad}	37.31± 0.04^{f}	29.43± 0.02^{e}	8.82± 0.03^{e}	5.27± 0.03^{e}	17.55± 0.05^{d}

NM1	4.16± 0.03[g]	35.11± 0.11[c]	31.95± 0.01[j]	9.04± 0.01[f]	8.43± 0.02[g]	11.59± 0.06[b]
NM2	3.27± 0.01[f]	42.58± 0.06[i]	30.31± 0.03[g]	7.37± 0.01[d]	9.25± 0.24[f]	11.45± 0.05[a]
BM1	1.85± 0.02[d]	36.13± 0.07[e]	28.32± 0.03[d]	7.38± 0.02[d]	5.15± 0.07[e]	21.41± 0.04[h]
BM2	1.71± 0.05[c]	37.90± 0.03[g]	24.90± 0.04[a]	10.61± 0.05[g]	4.85± 0.05[d]	20.15± 0.00[f]

[1]Values are means ± Standard Deviation of duplicate determinations;
[2]In any column, means bearing similar superscript are not significantly different (p≤0.05); 3MM1 = Monday Market 1, MM2 = Monday Market 2, CM1= Custom Market 1, CM2= Custom Market 2, TBM1= TashanBaga Market 1, TBM2= TashanBaga Market 2, NM1= Ngomari Market 1, NM2= Ngomari Market 2, BM1= Bulunkutu Market 1, BM2=Bulunkutu Market 2,

Essential Amino Acid Contents of the *Kuli kuli* Samples

Table 2 shows the essential amino acid contents of the kuli kuli expressed in mg/100g. The leucine content of all the samples analyzed varied significantly (p≥0.05). The values ranged from 6.68± 0.36 to 7.94± 0.06 in samples from Ngomari (NM1) and Tashan Baga (TBM1) markets, respectively. These values were higher than those reported by Batal et al. (2005) [12] in solvent extracted groundnut cakes which ranged from 3.13± 2.55 to 4.28± 0.16mg/100g. Furthermore, the isoleucine contents of the samples ranged from 3.10± 0.02 to 4.28± 0.36 in samples from Custom (CM1) and Tashan baga (TBM1) markets, respectively; the values varied significantly (p≥0.05) between the samples (Table 2), and were higher than those reported by Batal et al. (2005) [12] in similar products. On the other hand, no significant differences (p≤0.05) were observed in the lysine and phenylalanine contents of the kuli kuli samples analyzed. The values obtained ranged from 3.63± 0.12 to 4.85± 0.08 and 3.2± 0.07 to 4.14± 0.06 in samples from Custom (CM2) and Bulunkutu (TBM1) and Tashan Baga (TBM2) and Monday (MM1) markets, respectively; while concentration of tryptophan was observed to be the least among the essential amino acids determined and the values ranged from 0.71± 0.17 to 1.07± 0.02 in samples from Tashan Baga (TBM2) and Bulunkutu (BM1) markets, respectively. The low values of tryptophan recorded in this study are in agreement with low values recorded by Batal et al. (2005) [12] in a similar investigation.

Finally, significant differences (p≥0.05) were observed between the samples with regards to the valine, methionine and threonine contents of the kuli kuli samples from the various markets analyzed in the present study (Table 2). Their values ranged from 3.21± 0.00 to 3.71± 0.03, 1.28± 0.00 to 1.74± 0.03 and 2.44± 0.10 to 4.16± 0.02 in samples from Custom (CM1) and Bulunkutu (NM2), Bulunkutu (BM1) and Custom (CM2) and Bulunkutu (BM2) and Ngomari (NM2) markets, respectively. Also, significant differences (p≥0.05) were observed between the arginine contents of the samples which ranged from Monday (MM1) and Tashan Baga (TBM1) markets, and their values ranged from 4.11± 0.78 to 6.60± 0.06. These values are however, in line with those recorded by Batal et al. (2005) [12] in a similar study. The histidine contents of the analyzed samples ranged from 2.09± 0.01 to 2.47± 0.17 in samples from Custom (CM1) and Ngomari (NM2) markets, respectively, with no significant differences existing among all the samples. In general, the essential amino acid contents recorded in the samples of kuli kuli investigated in this study are in the decreasing order of Leucine > Arginine > Lysine > Phenylalanine > Threonine > Isoleucine > Valine > Histidine > Methionine > Tryptophan (Table 2).

Table 2: *Essential Amino Acid Contents (mg/100g) of Kuli kuli Sold in Selected Maiduguri Markets*[1]

Sample Code[3]	Parameters[2]									
	Leucine	Isoleucine	Lysine	Phenyl	Tryp	Valine	Meth	Threo	Argin	Histi
MM1	7.17± 0.17^{ab}	3.53± 0.24^{bcd}	3.79± 0.19^{a}	4.14± 0.06^{de}	0.90± 0.03^{abc}	3.55± 0.04^{b}	1.39± 0.09^{ab}	3.84± 0.01^{c}	4.11± 0.78^{a}	2.27± 0.16^{a}
MM2	7.37± 0.07^{c}	3.61± 0.19^{cd}	4.52± 0.31^{a}	3.70± 0.20^{abcd}	0.82± 0.06^{ab}	3.58± 0.10^{b}	1.36± 0.02^{ab}	2.68± 0.14^{ab}	6.08± 0.11^{bc}	2.20± 0.03^{a}
CM1	6.78± 0.10^{ab}	3.10± 0.02^{ab}	3.78± 0.13^{a}	3.43± 0.11^{abc}	0.80± 0.14^{ab}	3.21± 0.00^{a}	1.37± 0.01^{ab}	3.75± 0.00^{c}	5.67± 0.01^{bc}	2.09± 0.01^{a}
CM2	7.06± 0.06^{abc}	3.32± 0.11^{abc}	3.64± 0.12^{a}	3.52± 0.29^{abc}	1.06± 0.04^{bc}	3.69± 0.01^{bc}	1.74± 0.03^{d}	3.94± 0.05^{cd}	6.06± 0.04^{bc}	2.38± 0.14^{a}
TBM1	7.94± 0.06^{d}	4.28± 0.16^{d}	4.85± 0.08^{a}	3.87± 0.20^{cd}	0.79± 0.14^{ab}	3.73± 0.07^{bc}	1.39± 0.00^{ab}	2.64± 0.24^{ab}	6.60± 0.06^{cd}	2.27± 0.03^{a}
TBM2	6.70± 0.65^{a}	2.99± 0.02^{a}	3.73± 0.08^{a}	3.26± 0.07^{a}	0.71± 0.17^{a}	3.11± 0.01^{a}	1.31± 0.01^{a}	3.68± 0.07^{c}	5.26± 0.10^{b}	2.30± 0.13^{a}
NM1	6.68± 0.36^{a}	3.33± 0.12^{abc}	3.71± 0.27^{a}	3.76± 0.04^{abcd}	1.06± 0.04^{bc}	3.55± 0.04^{b}	1.39± 0.05^{ab}	3.71± 0.16^{c}	5.57± 0.27^{bc}	2.24± 0.07^{a}
NM2	7.31± 0.13^{c}	3.30± 0.03^{abc}	4.27± 0.03^{a}	3.78± 0.11^{bcd}	1.15± 0.05^{c}	3.71± 0.03^{bc}	1.57± 0.03^{c}	4.16± 0.02^{d}	5.80± 0.57^{bc}	2.47± 017^{a}
BM1	7.09± 0.08^{abc}	3.35± 0.08^{abcd}	4.28± 0.14^{a}	3.30± 0.03^{ab}	1.07± 0.02^{bc}	3.58± 0.04^{b}	1.56± 0.01^{c}	3.96± 0.02^{cd}	5.70± 0.14^{bc}	2.33± 0.22^{a}
BM2	7.38± 0.14^{c}	3.41± 0.01^{abcd}	4.55± 0.14^{a}	3.85± 0.04^{cd}	0.83± 0.06^{abc}	3.23± 0.03^{a}	1.28± 0.00^{a}	2.44± 0.10^{a}	6.12± 0.10^{bc}	2.20± 0.22^{a}

[1]Valuesare means ± Standard Deviation of duplicate determinations;
[2]In any column, means bearing similar superscript are not significantly different (p≤0.05);
[3]MM1 = Monday Market 1, MM2 Monday Market 2, CM1= Custom Market 1, CM2= Custom Market 2, TBM1= Tashan Baga Market 1, TBM2= Tashan Baga Market 2, NM1= Ngomari Market 1, NM2= Ngomari Market 2, BM1= Bulunkutu Market 1, BM2= Bulunkutu Market2.

Non-Essential Amino Acid Contents of the Kuli kuli Samples

Non-essential amino acid contents of the kuli kuli expressed in mg/100g is presented on Table 3. A significant difference (p≥0.5) was observed between all the samples in terms of all the non-essential amino acid contents. The highest values of the non-essential amino acids recorded in this study was glutamic acid which ranged from 11.72± 0.07 to 14.51± 0.01; while the lowest values of the acids recorded in the samples, 1.07± 0.01 to 1.38± 0.05, was cysteine. In overall, the values of the non-essential amino acids are in the descending order of Glutamic acid > Aspartic acid > Glycine > Alanine > Proline > Serine > Tyrosine > Cystiene (Table 3). Some of these values are either higher or lower than those obtained in similar studies such as Batal et al. (2005) [12].`

Table 3: *Non-Essential Amino Acid Contents (mg/100g) of Kulikuli Sold in Selected Maiduguri Markets*[1]

Sample Code[3]	Parameters[2]							
	Proline	Tyrosine	Cystiene	Alanine	Glut. acid	Glycine	Serine	Asp. acid
MM1	3.07± 0.01[a]	2.89± 0.03[b]	1.19± 0.01[bc]	3.96± 0.01[e]	11.73± 0.03[a]	3.56± 0.47[ab]	3.06± 0.04[a]	8.21± 0.02[a]
MM2	3.06± 0.01[ab]	3.12± 0.02[cd]	1.07± 0.01[a]	3.24± 0.01[a]	13.96± 0.03[d]	3.50± 0.02[ab]	3.21± 0.02[bc]	9.52± 0.03[h]
CM1	3.17± 0.07[ab]	2.60± 0.14[a]	1.20± 0.00[bc]	3.77± 0.05[bcd]	11.72± 0.07[a]	3.99± 0.01[bc]	3.10± 0.02[ab]	7.60± 0.03b
CM2	3.32± 0.02[c]	3.17± 0.07[cd]	1.34± 0.01[d]	4.11± 0.01[ef]	12.69± 0.02[b]	4.29± 0.01[c]	3.47± 0.01[ef]	8.85± 0.04[e]
TBM1	4.07± 0.01[c]	3.09± 0.01[c]	1.23± 0.02[c]	3.62± 0.02[b]	14.51± 0.01[e]	3.95± 0.01[bc]	3.42± 0.02[ef]	9.56± 0.05[h]
TBM2	3.04± 0.00[a]	2.56± 0.01[a]	1.38± 0.05[d]	3.34± 0.00[a]	11.47± 0.02[a]	3.35± 0.02[c]	3.12± 0.01[abc]	7.27± 0.04[a]
NM1	3.18± 0.06[ab]	2.89± 0.02[b]	1.22± 0.01[c]	3.82± 0.05[cd]	12.40± 0.10[b]	3.95± 0.01[bc]	3.25± 0.01[cd]	7.88± 0.01[c]
NM2	3.39± 0.10[b]	3.24± 0.04[cd]	1.35± 0.02[d]	4.22± 0.02[f]	13.23± 0.21[c]	4.15± 0.02[c]	3.56± 0.05[f]	9.06± 0.01[f]
BM1	3.35± 0.24[ab]	3.07± 0.02c	1.36± 0.06[d]	4.07± 0.05[ef]	12.56± 0.00[b]	4.18± 0.01[c]	3.37± 0.02[de]	8.70± 0.02[e]
BM2	3.28± 0.24[ab]	2.89± 0.02[b]	1.12± 0.03[ab]	3.27± 0.16[a]	13.48± 0.01[c]	3.39± 0.02[a]	3.04± 0.02[a]	9.28± 0.04[g]

1Valuesare means ± Standard Deviation of duplicate determinations;
2In any column, means bearing similar superscript are not significantly different (p≤0.05);
3MM1 = Monday Market 1, MM2 Monday Market 2, CM1= Custom Market 1, CM2= Custom Market 2, TBM1= Tashan Baga Market 1, TBM2= Tashan Baga Market2, NM1= Ngomari Market 1, NM2= Ngomari Market2, BM1= Bulunkutu Market1, BM2= Bulunkutu Market2.

Mineral Contents of Kuli kuli (mg/100g) Sold in some Maiduguri Markets

Legumes are some of the low cost sources of protein- rich foods, minerals and vitamins that have been important in alleviating malnutrition, especially in developing countries. Bambara groundnut is one of such essential legumes which provide a rich source of minerals [13]. Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life [14]. Minerals are chemical constituents used by the body in many ways.

Although they yield no energy, but have a synergistic role to play in many activities in the body [15]. The importance of mineral elements in human, animal and plant nutrition has been well recognized, as every form of living matter requires these inorganic elements or minerals for their normal life processes [16].

Table 4 shows the results of mineral analysis (mg/100g) obtained in this study. Significant differences ($p \geq 0.5$) were observed between the mineral contents of all the samples analyzed. Kulikuli from Tashan Baga Market (TBM2) had the highest calcium content of 60.50±0.15 whereas those from Monday (MM2) and Ngomari (NM1) markets had the lowest values of 17.00±0.15. Achimugu and Okolo (2020) [17] reported a much higher value of calcium, 2560.25 mg/100g, in their study. The huge variation could be as a result of the use of different varieties of groundnut and other ingredients during preparation. Magnesium, phosphorus, and potassium were found in concentrations that could contribute significantly in meeting the Recommended Daily Allowances (RDA) for these minerals for humans; while lower concentrations of iron and zinc were recorded in the samples (Table 4). The concentrations of the minerals in general, reflected their concentrations in the parent raw material used in the preparation of kuli kuli, which is the groundnut [18-21].

Table 4: *Mineral Contents (mg/100g) of Kuli kuli Sold in Selected Maiduguri Markets*[1]

Sample Code[3]	Parameters[2]					
	Ca	Mg	Fe	P	K	Zn
MM1	31.00±0.01^{abc}	2.00±0.01^{a}	4.00±0.01^{c}	71.00±0.19^{cd}	67.0±0.02^{b}	11.50±0.02^{a}
MM2	17.00±0.15^{a}	2.50±0.02^{a}	4.00±0.01^{bc}	64.00±0.02^{c}	63.5±0.04^{ab}	19.50±0.01^{bc}
CM1	20.00±0.15^{ab}	6.00±0.01^{a}	2.50±0.02^{abc}	41.00±0.02^{b}	87.50±0.55^{e}	19.73±0.01^{e}
CM2	60.50±0.00^{d}	1.50±0.01^{a}	2.00±0.01^{ab}	63.00±0.07^{c}	88.00±0.03^{d}	40.00±0.05^{f}
TBM1	53.50±0.47^{cd}	17.50±0.15^{b}	2.50±0.01^{abc}	19.00±0.04^{a}	78.00±0.05^{c}	30.00±0.03^{e}
TBM2	60.50±0.15^{d}	17.50±0.05^{b}	1.00±0.01^{a}	83.00±0.02^{d}	93.50±0.04^{e}	33.50±0.01^{e}
NM1	17.00±0.15^{a}	6.50±0.01^{a}	3.00±0.01^{abc}	70.00±0.18^{e}	93.70±0.01^{d}	42.00±0.02^{f}
NM2	42.50±0.05^{bcd}	18.00±0.06^{b}	3.50±0.01^{bc}	81.12±0.05^{e}	59.00±0.08^{a}	31.00±0.07^{e}
BM1	31.50±0.15^{abc}	8.00±0.01^{a}	2.50±0.01^{abc}	80.50±0.19^{cd}	62.50±0.05^{ab}	16.50±0.02^{b}
BM2	19.00±0.15^{abc}	8.00±0.02^{a}	2.50±0.01^{abc}	78.50±0.01^{cd}	89.50±0.02^{d}	25.50±0.03^{d}

[1]Valuesare means ± Standard Deviation of duplicate determinations;
[2]In any column, means bearing similar superscripts are not significantly different ($p \leq 0.05$);
[3]MM1 = Monday Market 1, MM2 Monday Market 2, CM1= Custom Market 1, CM2= Custom Market 2, TBM1= Tashan Baga Market 1, TBM2= Tashan Baga Market 2, NM1= Ngomari Market 1, NM2= Ngomari Market 2, BM1= Bulunkutu Market 1, BM2= Bulunkutu Market 2.

Conclusion

This study concludes that kuli kuli could be commercially produced as a high density nutrient product. The results of the proximate analysis show that kuli kuli is high in crude protein and crude fat, and that regular consumption of kuli kuli, particularly by the growing children, will significantly contribute to the daily

requirements for proteins, carbohydrates and fat. Carbohydrate is needed in large amounts in the body as up to 65% of the body's energy is obtained from carbohydrates. Proteins are needed for growth, maintenance and repair of worn out tissues, as fats also provide the body with the fat soluble vitamins, energy and provide padding for the vital organs in the body. In addition, kuli kuli can be used as a tool in fighting malnutrition especially among children when consumed regularly as a snack, or used in the formulation of weaning foods. The amino acid profile of kuli kuli shows that it contains all the essential amino acid in varying amounts. Regular consumption of kuli kuli will therefore contribute to the daily requirements for the essential amino acids for the maintenance of good health and wellness among the consuming populace. Also, the findings in this study indicate that regular consumption of kuli kuli could contribute significantly in meeting the daily mineral requirements of the consumers.

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