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Production and Nutritional Evaluation of Instantized *Kunun Gyada,* a Traditional Nigerian Beverage from Malted Sorghum (*Sorghum bicolor*) and Roasted Groundnut (*Arachis hypogeae*) Paste by Extrusion Cooking.

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Abstract: *The effect of malting and extrusion on the chemical properties of Kunun Gyada extrudates from malted sorghum flour and roasted groundnut paste was investigated. 27 samples using full factorial design were processed in a co-rotating twin-screw extruder. The results were subjected to statistical analyses to test for significant differences between treatments. Analysis of variance (ANOVA) was adopted using Statistix 9; Version 9.1 (2012) Statistical Package. There was increase in proximate mean composition of germinated sorghum flour, moisture 11.20 to 11.23%, ash 1.23 to 1.37%, and crude protein 8.50 to 9.13% with decrease in both crude fat and carbohydrates from 3.50 to 3.17% and 77.70 to 74.27% respectively. Proximate composition of roasted groundnuts paste showed increase in crude fat and decrease in carbohydrates, moisture content, ash, and crude protein. Crude protein content of extrudates increased from 19.13% (malted sorghum) to 22.9%. Feed moisture content increased from 0.4g/ml to 0.7g/ml. Among all the amino acids at extrusion parameters 35%, 20%, 110^{o}C, Methionine had the lowest value of 1.63g and Glutamic acid has the highest value of 17.28g. From essential amino acids, Methionine had the lowest value of 1.63g, Leucine had the highest value of 7.34g and lysine had 3.54g at the same design point 23 (35% 20% 110^{o}C). In non-essential amino acids, Cystine had the lowest value of 2.40g and Glutamic acid had the highest value of 17.28g at 35% 20% 110^{o}C. The results of proximate mean composition and amino acid profile contents of extrudates indicates increase in nutrients which may be as a result of the increase in roasted groundnuts paste, use of malted sorghum flour, and the application of extrusion cooking which enhances the nutrient densities of cereal gruels and improve the product quality. The extrudate with design point 20 for its high protein content and required essential amino acid values has better nutritional potential for commercial production of kunungyada in Nigeria.*
Keyword: *Extrusion, Malting, Roasting, Kunungyada, Sorghum.*

I. Introduction

Cereals form an important part of the diet of many people in the developing countries especially in Nigeria. These include maize, sorghum, millet, and rice. Cereals are associated with food and drinks throughout the history of Mankind. This close association with people's lives may have been because cereals are easy to cultivate, transport, store, and are adoptable to different environment. Cereals are used mostly as foods and feeds (Gibson *et al.,* 1998). Cereals are also used for making porridges and starch based meals which are used for breakfast formulations. The outlook for world cereal production in 2015 has improved since the previous report in May, on expectations of larger wheat, coarse grains (maize, sorghum and millet) and rice harvests. FAO's latest forecast for global cereal production in 2015 stands at 2524 million tonnes almost 15 million tonnes higher than it was reported in May. At this level, world cereal production will be 1 percent or 25.6 million tonnes, lower than the record in 2014 (FAO, 2015).

Sorghum is a cereal grain widely grown across the world. Sorghum survives draught condition better than maize and other cereals. It is commonly grown in areas where rainfall is low and unpredictable especially in the savannah grassland in Nigeria. It is a valuable food crop because it contains a higher percentage of protein than maize and the protein is also of better quality, with respect to amino acid profile. Sorghum is also rich in calcium and iron. In some parts of Asia and Africa it is regarded as low-class foods for poor people (Zhang and Harmaker, 1998). World Sorghum Production 2015/2016, June 2015, the United States Department of Agriculture (USDA) estimates that the World Sorghum production will be 65.34 million metric tonnes, around 0.06 metric tonnes less than the previous month's projection. Sorghum production in 2015 was 64.08 million tonnes. 2015's 65.34 estimated million tonnes could represent an increase of 1.24 million tonnes or a 1.94% in sorghum production around the world. Sorghum production by country; United States is leading with 11,050,000 metric tonnes, followed by Mexico with 7, 800,000 metric tonnes, Nigeria 6,150,000 metric tonnes, Sudan 5,500,000 metric tonnes, India 5,500,000 metric tonnes, Argentina 4,500,000 metric tonnes, Ethiopia 4,000,000 metric tonnes, China 2,600,000 metric tonnes, Australia 2,100,000 metric tonnes, Brazil 2,000,000 metric tonnes, Burkina Faso 1,900,000 metric tonnes, Mali 1,300,000 metric tonnes, Cameroun 1, 150,000 metric tonnes, Niger 1,100,000 metric tonnes, Chad 900,000 metric tonnes and Tanzania 840,000 metric tonnes (USDA, 2015).

Groundnut also known as peanut or monkey-nut is specie in the legume family (*Fabaceae*). In West Africa, groundnut grows well in Southern Mali and adjacent regions of the Ivory Coast, Burkina Faso, Ghana, Nigeria and Senegal (Gordon, 2001). They are energy dense foods because of their oil, and they are rich in vitamins and minerals (Eke-Ejiofor *et al.,* 2012). Foods containing roasted groundnuts have high consumer acceptance because of their unique roasted peanut flavour. Peanut are continually applied for the preparation of new and improved food products (Eke-Ejiofor *et al.,* 2012).

Extrusion cooking is a high- temperature, shot-time process in which moistened, expansive, starchy and/or protenacious food materials are plasticised and cooked in a tube by a combination of moisture, pressure, temperature and mechanical shear, resulting in molecular transformation and chemical reactions (Castells *et al*., 2005). This technology has some unique positive features compared with other heat processes; the material is subjected to intense mechanical shear. Extrusion cooking is preferable to other food processing techniques in terms of continuous process with high productivity and significant nutrient retention, owing to high temperature and short time required (Guy, 2001). Nutritional concern about extrusion cooking is reached at its highest level when extrusion is used specifically to produce nutritionally balanced or enriched foods (Plahar *et al*., 2003).

To improve the nutrient intake of communities in Africa especially children, several food preparations technology have been advocated that can effectively increase the nutrient density of porridges and reduce the risk of malnutrition. The process has found numerous applications, including increasing numbers of ready-to-eat cereals; salty and sweet snacks; co-extruded snacks; indirect expanded products; an expanded array of dry pet foods and fish foods; textured meat-like materials from defatted high-protein flours; nutritious precooked food mixtures for infant feeding; and confectionery products (Eastman *et al*., 2001).

The current varieties of food products obtained through extrusion cooking are impressive and continue to expand (Harper, 1984). There is possibility of extrusion cooking of mixed malted sorghum flour and roasted groundnuts paste to produce kunun gyada, this will provide a useful alternative in highly nutritious food products and improve on the traditional methods of preparation which form the thrust of this work.

II. Materials And Methods

Malting of Sorghum

Sorghum grains (*Sorghum bicolor*) obtained from *Kasuwan Kuturu* in Mubi, Adamawa State, Nigeria, were cleaned and germinated using the method of Elkhalita and Bernhardt, (2010). The sorghum grains were soaked in clean water for 24 hours at room temperature (30^oC) with two changes of water to ensure removal of dirt and other contaminants. The carefully drained soaked grains were spread out on a jute bag saturated with water on a clean floor covered with another jute bag under shade for two days at room temperature (25 -30^oC) and water was sprayed on the grains after every six hours to control the moisture level. The germinated grains were sundried for three days at temperatures of about 35 – 40^oC.

Flour Preparation

The root and shoot portions were manually removed by gently pounding using pestle and mortar. The polished dried malted sorghum grains were ground to fine homogenous powder using a laboratory mill (SPI Supplies PA, USA) and passed through a 100µm mesh screen. The milled sample was packed in a plastic container and stored at low temperature until required for use.

Paste Preparation

The groundnuts (*Arachis Hypogeae*) variety *Virginia bunch* was purchased in *Kasuwan Kuturu* in Mubi, Adamawa state, Nigeria. The kernels were red, uniform, and medium in size. After sorting, cleaning and grading, it was mildly roasted using clean heated dry sand at about 98^oC in a clay pot. The roasted groundnut was blanched (removing the husk) by robbing between two clean wooden surfaces to break and remove the husk from the groundnut seeds and winnowed to separate the husk from the seeds. The cleaned groundnuts were milled into a paste of golden brown colour using disc attrition mill.

Blend Preparation and Moisture Adjustment

One thousand grams weight blend of samples were obtained by mixing the given percentage of groundnuts paste in each with the sorghum malt flour and the total moisture content of blends were determined on wet weight basis (Filli *et al.* 2011).

Experimental Design

A three- factor three levels full factorial design was adopted for the study to determine the physicochemical and sensory properties of extrudates from the blends of malted sorghum flour and roasted groundnuts paste based kunu gyada (Filli *et al.*, 2010). Details of the Experimental Design in their Coded and Natural form are shown on Tables 1 and 2.

Extrusion Cooking

The extrusion cooking was performed using SLG65 Twin Screw Extruder, Jinansaibainuo Technology Development Co; LMD in The Federal Polytechnic Mubi, Adamawa State, Nigeria. The extruder has three independent heating zones and the samples were extruded at 100, 110 and 120^oC respectively. The length to diameter (L/D) of the extruder was 20:1. The diameter of the die was 4mm with die length of 27mm. The moisture content of different blends was adjusted by addition of a predetermined amount of water to 15, 20 and 25% respectively. The extruder was fed manually through a screw operated conical hopper.

Proximate Analysis

Unmalted and malted sorghum flours, unroasted and roasted groundnut pastes, and ground samples of extrudates for proximate composition (protein, amino acid profile, fat, carbohydrates, ash, and moisture) were analysed using these procedures. Protein was determined by Kjeldhal method using KDN-2C Nitrogen/Protein determinator. Percentage nitrogen was converted into crude protein by multiplying with the conversion factor 6.25. The method of Blamire (2003) was adopted for the calculation of the crude protein. The fat content was analysed using the methods described by (AOAC 2000). The carbohydrates was determined by difference 100 – [protein (%) + fat (%) + moisture (%) + ash (%)] as described by Egan *et al*, (1981). The amino acid profile in the known extrudate samples was determined using methods described by Benitez (1989). The amount of each amino acid present in the sample was calculated in g/16gN or g/100g protein. Ash content was determined using the methods described by Onwuka, (2005). The moisture content was determined as described by AOAC (2006).

Statistical Analysis

The results were subjected to statistical analyses to test for significant differences between treatments. Statistix 9, version 9.1 (2012) Statistical package was used. ANOVA was adopted to test for significant difference at $p < 0.05$ level of significance for the sensory evaluation. Values were means of triplicate analyses.

III. Results

Proximate Composition of the Raw Materials

The results of proximate compositions of the raw materials are presented in Tables 3 and 4. The protein content of unroasted groundnuts 27.8% showed a value higher than roasted groundnuts 26.9%, similarly fat content increased from 49% to 53%. Carbohydrates contents decreased from 20.6% to 19.3%. Moisture level decreased from 3.8% to 2.2% and the ash content also decreased from 2.7% in unroasted groundnuts to 2.5%. The protein content of germinated sorghum flour 9% was higher than the non-germinated sorghum flour 8.4%. The fat content was higher in non- germinated sorghum flour 3.3% than the germinated sorghum flour 3.2%. Flour from germinated sorghum had slightly higher moisture content 11.2% than non-germinated sorghum flour 11.1%. The germinated sorghum flour had higher ash content 1.4% than the non-germinated sorghum 1.2%. While the carbohydrates content of unmalted sorghum flour was 77.6% compared to 74.3% in the malted sorghum.

Proximate Composition of Extrudates

The mean values of the proximate composition of extrudates are presented in Table 5. The crude protein content values increased from 9.13% for sorghum malt to 16.06% and 22.89% for design points 11 and 20 respectively with increase in feed composition from 15 to 35% and decrease in barrel temperature from 120^oC to 110^oC as the level of enrichment with roasted groundnuts paste increased. The fat values increased from 6 to 23%, the result showed that increase in both feed composition (15 to 35%) and barrel temperature (110 to 120^oC) increased the fat content. The moisture content of extrudates varies between 3.17 to 5.50%. The ash content of the extrudates reduced from 3 to 1% with sample formulation ratios of 15% feed composition, 15% moisture content, 120^oC barrel temperature and 35% feed composition, 25% moisture content, 120^oC barrel temperature. The carbohydrates contents of the extrudates reduced from 72 to 53% with sample formulation ratios of 15% feed composition, 15% moisture content, 110^oC barrel temperature and 35% feed composition, 25% moisture content, 110^oC barrel temperature respectively.

Table 1. Proximate Composition of Non-germinated and Germinated Sorghum Flour (%)

Composition	Non-germinated sorghum	Germinated sorghum
Moisture	11.20 ± 0.10a	11.023 ± 0.06a
Ash	1.23 ± 0.06a	1.37 ± 0.06b
Crude protein	8.50 ± 0.10a	9.13 ± 0.06b
Crude fat	3.50 ± 0.10a	3.17 ± 0.06b
Carbohydrates	77.70 ± 0.10a	74.27 ± 0.06b

Any two means in the same column followed by the same letter are not significantly different (p>0.05).

Table 2. Proximate Composition of Raw and Roasted Groundnuts Paste (%)

Composition	Raw groundnuts paste	Roasted groundnuts paste
Moisture	3.77 ± 0.06[a]	2.30 ± 0.10[b]
Ash	2.63 ± 0.12[a]	2.60 ± 0.10[a]
Crude protein	27.77 ± 0.15[a]	26.80 ± 0.10[b]
Fats	49.33 ± 1.53[a]	53.33 ±1.53[b]
Carbohydrates	20.73 ± 0.15[a]	19.40 ± 0.10[b]

Any two means in the same column followed by the same letter are not significantly (p>0.05).

Table3, Experimental Design and Observed Values of Proximate Mean Composition of Extrudates (%)

1	15	15	100	17.29±0.04lm	11.00±1.02l	66.71±0.61j	2.00±0.04g	3.03±1.02b
2	15	15	110	16.98±1.02m	7.00±0.04op	72.00±1.01a	1.00±0.03g	3.00±0.02c
3	15	15	120	16.67±0.04o	7.33±0.02n	67.50±0.02b	3.00±0.05h	4.50±0.02a
4	15	20	100	17.04±1.02m	12.00±1.02k	66.90±0.01i	1.00±0.02g	3.00±0.01c
5	15	20	110	16.49±0.07n	11.33±0.03l	67.68±0.05h	2.00±5.77f	3.50±0.06b
6	15	20	120	17.70±0.02k	9.60±1.00m	67.10±0.10f	2.00±0.60i	3.17±1.02b
7	15	25	100	18.60±0.06ij	8.00±0.03n	67.90±0.06g	1.00±0.27cd	4.67±0.01c
8	15	25	110	17.32±1.02klm	6.00±1.02q	70.17±0.01d	2.00±1.02a	5.50±1.02b
9	15	25	120	17.51±0.04kl	6.67±0.03p	69.32±0.03e	2.00±0.03d	4.50±0.03b
10	25	15	100	22.27±0.15b	15.33±0.12h	57.85±0.05s	0.99±1.02f	3.50±0.03c
11	25	15	110	16.06±0.03o	8.33±0.21n	71.11±0.01c	1.00±0.09f	3.50±0.02c
12	25	15	120	20.32±1.02e	15.00±0.85a	49.15±0.04z	2.00±0.03f	3.50±0.02b
13	25	20	100	21.11±0.02cd	15.00±0.04h	58.40±5.77r	2.00±0.02f	3.50±0.02b
14	25	20	110	18.82±0.06ghi	16.33±0.02g	68.85±0.11q	2.00±0.08e	4.00±1.02b
15	25	20	120	21.89±0.02b	13.00±0.02j	60.61±0.07o	1.00±0.05f	3.50±0.03c
16	25	25	100	18.62±0.11hij	13.33±0.24ij	62.55±0.02n	1.00±1.02d	4.50±0.04c
17	25	25	110	19.03±1.02gh	12.00±0.02k	62.97±0.11lm	1.00±0.32bc	4.83±0.07c
18	25	25	120	19.18±0.16fg	10.00±0.04m	64.33±0.21k	1.00±0.27a	5.33±0.03c
19	35	15	100	21.42±0.10c	13.67±0.34i	60.34±0.19p	1.00±1.02f	3.50±0.08c
20	35	15	110	22.89±0.72a	18.00±0.13f	54.61±0.11u	1.00±0.09f	3.53±0.07c
21	35	15	120	18.21±0.11j	23.00±0.04b	54.29±0.21v	1.00±0.02f	3.50±0.04c
22	35	20	100	17.16±0.02lm	18.66±0.27e	58.17±0.19r	2.00±0.06e	4.00±0.09b
23	35	20	110	18.25±0.14j	13.67±0.14i	59.08±0.09l	1.00±0.07f	3.00±0.05c
24	35	20	120	18.61±1.02ij	15.00±0.22h	62.90±1.02m	1.00±0.03f	4.50±0.09c
25	35	25	100	18.43±0.22ij	20.67±0.12d	53.8±0.10w	2.00±0.08b	5.00±0.03b
26	35	25	110	20.83±0.12d	21.67±0.34c	53.00±1.02x	1.00±0.04h	3.50±0.05c
27	35	25	120	19.52±0.21f	18.67±0.09e	56.80±0.02t	1.00±0.02e	4.00±0.07c

Table 4. Experimental Design and Observed Mean Values of Essential Amino Acids Profile of Extrudates (g/100g Protein)

Design point	X_1	X_2	X_3	Arginine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Valine
1	15	15	100	6.95±0.07m	2.23±0.02b	3.06±0.03jk	5.63±0.03gh	3.16±0.03jk	1.10±0.02b	3.98±0.03kl	2.06±0.03m	3.60±0.03kl
2	15	15	110	6.79±0.02o	2.22±0.04b	3.04±0.03k	5.62±0.02gh	3.15±0.03jk	1.09±0.04b	3.96±0.02klm	2.04±0.03mn	3.57±0.02lm
3	15	15	120	6.53±0.04r	2.08±0.03b	3.00±0.03k	5.42±0.03hi	3.14±0.02k	1.06±0.02b	3.93±0.03klm	2.00±0.03no	3.54±0.02m
4	15	20	100	6.34±0.01s	2.05±0.03b	2.90±0.03m	5.30±0.03hijk	3.07±0.02l	1.06±0.03b	3.92±0.08lm	1.97±0.01op	3.47±0.01n
5	15	20	110	6.22±0.02t	2.04±0.03b	2.72±0.03n	5.09±0.03ijkl	3.00±0.04mn	1.05±0.02b	3.82±0.03m	1.95±0.03p	3.26±0.020
6	15	20	120	6.06±0.03u	1.99±0.03b	2.68±0.03o	5.04±0.03jkl	2.97±0.02no	1.03±0.04b	3.75±0.04n	1.94±0.04p	3.23±0.04op
7	15	25	100	5.69±0.02v	1.98±0.05b	2.55±0.02p	4.98±0.03kl	2.96±o.o1no	0.98±0.03b	3.67±0.02o	1.89±0.03q	3.20±0.04pq
8	15	25	110	5.44±0.03w	7.69±9.95a	2.50±0.03q	4.27±1.17m	2.96±0.03no	0.89±0.02b	3.56±0.02p	1.84±0.02r	3.15±0.02q
9	15	25	120	5.10±0.03x	1.84±0.03b	2.43±0.03r	4.87±0.04l	2.94±0.03o	0.84±0.03b	3.47±0.01q	1.78±0.03s	3.15±0,02q
10	25	15	100	9.68±0.03b	2.35±0.03b	3.70±0.03c	6.56±0.01cd	3.42±0.03bc	1.43±0.03b	4.65±0.02r	2.66±0.0g	4.23±0.02e
11	25	15	110	9.17±0.02c	2.29±0.03b	3.54±0.02e	6.36±0.02cde	3.39±0.03cd	1.37±0.02b	4.36±0.02e	2.56±0.01h	4.12±0.08f
12	25	15	120	8.24±0.02g	2.23±0.03b	3.29±0.03g	6.16±0.03ef	3.27±0.02gh	1.53±73.a	4.20±0.02h	2.46±0.02i	3.95±0.03h
13	25	20	100	7.33±0.02k	2.19±0.03b	3.07±0.02jk	5.87±0.02fg	3.19±0.03ij	1.17±0.03b	4.06±0.02i	2.23±0.03k	3.80±0.02i
14	25	20	110	6.65±0.02q	2.10±0.03b	2.99±0.03l	5.36±0.02hij	3.13±0.07k	1.14±0.08b	3.99±0.02j	2.12±0.03l	3.58±0.08kl
15	25	20	120	6.70±0.03p	2.13±0.04b	2.99±0.03l	5.55±0.02gh	3.06±0.03l	1.14±0.03b	3.99±0.04k	2.29±0.02j	3.57±0.02lm
16	25	25	100	6.86±0.02n	2.14±0.02b	3.04±0.03k	6.00±0.03ef	3.04±0.03lm	1.20±0.03b	3.99±0.04k	2.47±0.02i	3.59±0.02kl
17	25	25	110	6.93±0.02m	2.14±0.03b	3.10±0.02ij	6.30±0.03de	3.00±0.03mn	1.29±0.02b	3.96±0.01klm	2.70±0.03g	3.63±0.03jk
18	25	25	120	7.00±0.02l	2.15±0.03b	3.13±0.02i	6.73±0.02bc	2.98±0.01no	1.36±0.03b	3.98±0.03kl	2.83±0.03f	3.67±0.02j
19	35	15	100	8.55±0.01f	2.29±0.03b	3.44±0.02f	7.12±0.03a	3.14±0.03k	1.47±0.03b	4.49±0.03g	2.99±0.03e	4.13±0.02f
20	35	15	110	8.70±0.03e	2.34±0.03b	3.50±0.03e	7.20±0.03a	3.23±0.03hi	1.53±0.02b	4.49±0.03e	3.07±0.01d	4.27±0.01e
21	35	15	120	9.07±0.02d	2.37±0.02b	3.59±0.03d	7.27±0.01a	3.29±0.03fg	1.54±0.02b	4.80±0.02d	3.17±0.02c	4.47±0.02c
22	35	20	100	9.67±0.02b	2.41±0.04b	3.77±0.02b	7.32±0.03a	3.40±0.03cd	1.59±0.03b	5.04±0.03b	3.29±0.02b	4.63±0.02b
23	35	20	110	9.85±0.02a	2.42±0.04b	3.82±0.03a	7.34±0.02a	3.54±0.04a	1.63±0.02b	5.16±0.02a	3.38±0.01a	4.83±0.03a
24	35	20	120	8.06±0.03h	2.37±0.02b	3.67±0.01c	6.99±0.03ab	3.47±0.02b	1.49±0.02b	4.97±0.02c	3.04±0.03d	4.63±0.02b
25	35	25	100	7.87±0.03i	1.33±0.03b	3.46±0.01f	6.34±0.04de	3.35±0.02de	1.34±0.03b	4.57±0.02f	2.70±0.02g	4.34±0.03d
26	35	25	110	7.55±0.02j	2.31±0.04b	3.27±0.02g	6.05±0.02ef	3.33±0.02ef	1.30±0.03b	4.36±0.02h	2.44±0.03i	4.04±0.03g
27	35	25	120	7.35±0.02k	2.29±0.02b	3.19±0.02h	5.88±0.08fg	3.26±0.02gh	1.22±0.02b	4.24±0.03i	2.23±0.02k	3.83±0.03i

X_1 = Feed Composition, X_2 = Moisture Content, X_3 = Barrel Temperature

Table 5. Experimental Design and Observed Mean values of Non-Essential Amino acid Profile of Extrudates (g/100g Protein)

	Independent variables			Values in their natural form							
Design points	X_1	X_2	X_3	Alanine	Aspartic acid	Cystine	Glutamic acid	Glycine	Proline	Serine	Tyrosine
1	15	15	100	3.51±0.02f	9.84±0.04b	1.09±0.03b	13.36±0.03m	3.58±0.03j	3.28±0.02h	3.01±0.03l	2.89±0.03j
2	15	15	110	3,47±0.02f	9.93±0.06b	1.07±0.03b	13.25±0.05n	3.44±0.02k	3.07±0.02ij	2.96±0.02m	2.86±0.01jk
3	15	15	120	3.37±0.01h	9.87±0.03b	1.07±0.02b	12.88±0.03p	3.36±0.03l	2.84±0.04l	2.95±0.02mn	2.83±0.02k
4	15	20	100	3.26±0.06i	9.75±0.02b	1.08±0.03b	12.75±0.03q	3.35±0.01l	2.45±0.04n	2.88±0.07op	2.76±0.02l
5	15	20	110	3.22±0.03j	9.58±0.03b	1.02±0.03b	12.21±0.02r	3.36±0.04l	1.99±0.06q	2.87±0.05op	2.74±0.04l
6	15	20	120	3.20±0.01jk	9.49±0.02b	0.98±0.01b	12.03±0.04s	3.34±0.02l	2.08±0.03p	2.79±0.02q	2.57±0.02m
7	15	25	100	3.16±0.01kl	9.14±0.07b	0.94±0.02b	11.87±0.02t	3.23±0.02n	2.33±0.05o	2.65±0.02r	2.52±0.01n
8	15	25	110	3.11±0.02m	8.96±0.02b	0.91±0.03b	11.03±0.05u	3.13±0.03o	2.61±0.03m	2.59±0.03s	2.47±0.02o
9	15	25	120	2.98±0.03o	8.89±0.02b	0.98±0.05b	10.96±0.04v	3.06±0.03p	2.87±0.02l	2.57±0.02s	2.34±0.04p
10	25	15	100	3.89±0.02c	11.26±0.03b	1.62±0.03b	16.38±0.02f	4.36±0.04c	3.37±0.02b	3.96±0.04d	3.51±0.03b
11	25	15	110	3.87±0.02c	11.18±0.03b	1.54±0.07b	16.09±0.03g	4.19±0.02e	3.84±0.02b	3.93±0.02de	3.41±0.02+d
12	25	15	120	3.66±0.02d	10.87±0.02b	1.35±0.03b	15.56±0.04i	3.88±0.04h	3.42±0.04f	3.91±0.02ef	3.06±0.02h
13	25	20	100	3.47±0.02g	3.47±0.04a	1.32±0.001b	14.35±0.02j	3.55±0.03j	3.08±0.03i	3.88±0.01f	2.87±0.02j
14	25	20	110	3.21±0.03j	9.16±0.04b	1.22±0.03b	12.88±0.01p	3.25±0.03mn	2.88±0.03l	2.86±0.03p	2.74±0.04l
15	25	20	120	3.18±0.01jk	9.23±0.02b	1.31±0.02b	13.07±0.02o	3.28±0.02m	2.94±0.02k	2.91±0.02no	2.73±0.02l
16	25	25	100	3.13±0.02lm	9.27±0.01b	1.58±0.01b	13.45±0.03l	3.34±0.02l	2.94±0.02k	3.11±0.03k	2.86±0.03jk
17	25	25	110	3.11±0.02m	9.31±0.02b	1.67±0.02b	13.97±0.02k	3.48±0.01k	3.03±0.02j	3.25±0.02j	2.97±0.02i
18	25	25	120	3.06±0.02n	9.34±0.04b	1.75±0.03b	14.34±0.03j	3.57±0.03j	3.07±0.02ij	3.34±0.03i	3.05±0.03h
19	35	15	100	3.57±0.02e	10.76±0.03b	2.07±0.02b	16.84±0.03d	3.96±0.02g	3.67±0.02d	3.93±0.03g	3.36±0.03ef
20	35	15	110	3.65±0.02d	10.96±0.03b	2.17±0.02b	17.07±0.01c	4.07±0.04f	3.77±0.02c	4.06±0.05c	3.39±0.02de
21	35	15	120	3.98±0.01b	11.70±0.03b	2.28±0.02b	17.18±0.05b	4.31±0.03d	3.88±0.02b	4.18±0.01b	3.46±0.02c
22	35	20	100	4.03±0.03a	11.69±0.50b	2.41±0.04b	17.25±0.03a	4.46±0.03b	4.07±0.02a	4.21±0.02b	3.53±0.02b
23	35	20	110	4.05±0.03a	12.30±0.03b	2.40±0.02b	17.28±0.03a	4.57±0.01a	4.09±0.02a	4.26±0.03a	3.67±0.02a
24	35	20	120	3.97±0.03b	11.99±0.02b	2.04±0.01b	17.06±0.02c	4.27±0.02d	3.88±0.04b	4.21±0.02b	3.53±0.02b
25	35	25	100	3.65±0.02d	11.65±0.03b	8.53±11.55a	16.75±0.03e	4.08±0.04f	3.55±0.03e	3.87±0.02fg	3.34±0.03f
26	35	25	110	3.52±0.02f	11.98±0.01b	1.56±0.03b	15.78±0.02h	3.96±0.02g	3.42±0.01f	3.56±0.02h	3.19±0.07g
27	35	25	120	3.46±0.04g	10.07±0.02b	1.35±0.03b	14.36±0.04j	3.80±0.03i	3.37±0.02g	3.24±0.03j	3.05±0.h

Amino Acids Profile of Extrudates

The results of both essential and non-essential amino acids are shown in Tables 4 and 5 respectively. All the amino acids showed highest value at design point number 23 with extrusion parameters 35% feed composition, 20% feed moisture content, and 110^{o}C barrel temperature which also has high general acceptability value of 6.4. Among all the amino acids at extrusion parameters 35%, 20%, 110^{o}C, Methionine had the lowest value of 1.63g and Glutamic acid has the highest value of 17.28g. From essential amino acids, Methionine had the lowest value of 1.63g, Leucine had the highest value of 7.34g and lysine had 3.54g at the same design point 23 (35% 20% 110^{o}C). In non-essential amino acids, Cystine had the lowest value of 2.40g and Glutamic acid had the highest value of 17.28g at 35% 20%

IV. Discussion

Proximate Compositions of Raw Materials and Extrudates

The results of the proximate composition of raw and extruded samples are shown in Tables 4 and 5. The high crude protein content of the roasted groundnut paste may have accounted for the increase in the crude protein content of extrudates; the linear increase in protein content of the extruded sample was also reported for Fura as a result of increase in the amount of cowpea flour from15 to 35% (Filli *et al.*, 2011).The decrease in the fat content may be as a result of its use as an energy source during germination and/or utilization by microorganisms during soaking and germination (Chavan and Khadam, 1989b). The low carbohydrate content of malted sorghum flour, 74.3%, could be due to gradual degradation of starch by enzymes during germination. Soaking and germination have been reported to enhance the lost of starch (Chavan and Khadam, 1989a).The higher ash content 3% could be attributed to loss of dry matter, especially carbohydrates, through respiration during sprouting (Chavan and Khadams, 1989a). The variation in the moisture content, 11.1% to 11.21% observed in the unmalted sorghum flour and the malted flour samples could be as a result of pre-processing methods such as soaking, germination, drying and storage conditions. Moisture content of malted sorghum flour was higher than that of the extrudates and roasted groundnuts paste. The result agrees with the work of Badrie and Mellowes (1991) who reported that increasing extrusion temperature from 105^{o}C to 150^{o}C reduced moisture level in extrudates.

Amino Acids Profile of Extrudates

All amino acids of extrudates increased with increase in feed composition and decreased with increase in both feed moisture content and barrel temperature.

V. Conclusion

Germination and extrusion cooking of cereal grains and legumes have been shown to be effective in improving their nutritive value (Chavan and Khadams, 1989a; 1989b). The result of proximate mean composition of extrudates indicates increase in nutrients which may be as a result of the increase in roasted groundnuts paste, use of malted sorghum flour, and the application of extrusion cooking which improve the product quality.

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