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Nutritional Composition of Five Varieties of Pap Commonly Consumed in Maroua (Far-North, Cameroon)

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The aim of this study was to determine the nutritional composition of five varieties of pap (cereal product) commonly consumed in Maroua, city of the Far-North Region of Cameroon. The proximate composition (moisture, ash, protein, lipid, and crude fibre) was determined by standard AOAC methods. Minerals (calcium, magnesium, sodium, potassium, iron, zinc, copper and manganese) were determined by atomic absorption spectrophotometry and phosphorus was determined colorimetrically. Amino acid composition was determined by ion-exchange chromatography. All the pap varieties had a very high carbohydrate content (79.47–85.29 g/100 g dry matter). Appreciable levels of phosphorus and potassium were recorded in all the pap varieties (137.5–231.0 mg/100 g dry matter and 198.20–322.22 mg/100 g dry matter, respectively). Consumption of each pap (100 g) by children 1–2 year old would meet 9.86–17.46% and 0.08–19.51% of their daily recommended intake respectively for protein and minerals. Leucine and glutamic acid were the most abundant essential amino acids and non-essential amino acids respectively in the pap. Essential amino acids in most of the pap samples met the recommended children requirement of the FAO/WHO/UNU for 1–2 year old children except methionine+cysteine and lysine.

INTRODUCTION

Food security is not achieved in most developing countries [Black et al., 2008] and poverty has a central role in malnutrition worldwide, as poor nutrition affects the individual from conception to death [Gibney et al., 2002]. There is a very high incidence of malnutrition, especially of protein and micronutrient deficiencies in developing countries [FAO, 2010]. These have led to many illnesses such as kwashiorkor, marasmus, goitre, obesity, diabetes, cancer and cardiovascular illnesses [Latham, 2001]. The four most important micronutrients in human nutrition are vitamin A, iron, and iodine and zinc [Hemalatha et al., 2007]. Iron deficiency is the most widespread nutritional deficiency [Hemalatha et al., 2007], afflicting over half of the world's population in 2000, and increasing particularly among poor women in developing countries [Welch & Graham, 2005].

In Cameroon, approximately 45,000 children die each year due to malnutrition [UNICEF Cameroon, 2009]. In general, malnutrition varies spatially depending on the ecological and environmental conditions and socioeconomic factors. The nutritional status of children under 5 years

* Corresponding Author: Tel.: 237 677 97 43 24; E-mail: rponka@yahoo.fr (R. Ponka) in the Far-North Region of Cameroon remains a very serious health problem because the prevalence of chronic malnutrition (35.7%), acute malnutrition (11.7%) and underweight (36.4%) are above the national average [INC, 2006]. One of the causes of malnutrition in Cameroon is the lack of the nutritional value of different traditional foods ready for consumption [CFSVA, 2007].

Information on the nutritional content of ready-to-eat food may contribute to the evaluation of the nutritional status, and investigation into the relationships between diet, health and disease [Pennington, 2008]. However, data on the nutritional value of dishes of the Far-North Region of Cameroon are limited. Due to the fact that an important part of human diet in Maroua city is composed of cereal grains product the aim of this study was to determine to nutritional composition of five varieties of pap (cereal product) commonly consumed in Maroua, city of the Far-North Region of Cameroon.

MATERIALS AND METHODS

Sample collection

A survey of the cooking methods and consumption of the pap was conducted in 60 households chosen at random in Maroua, city of the Far-North of Cameroon. Each of the 5 types of pap commonly consumed was collected from

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6 different households. The 30 collected samples were transported to the laboratory for chemical analyses.

Proximate chemical composition

Moisture, ash, protein, lipid, and crude fibre in the samples were determined by the recommended methods of the Association of Official Analytical Chemists [AOAC, 1999]. Moisture content was determined by drying fresh sample in an oven at 105°C until constant weight. Ash was obtained by incineration in a muffle furnace of the dried material at 550°C for 48 h. The organic nitrogen content was quantified using the micro Kjeldahl method, and crude protein content was estimated by multiplying the organic nitrogen content by a factor of 6.25. Lipid content was determined using a Soxhlet apparatus, with petroleum ether to extract the lipid. Crude fibre content was determined by successive digestion of the defatted sample with 0.26 N sulphuric acid and 0.23 N potassium hydroxide solutions. All samples were analysed in triplicate. Total carbohydrate content was calculated by difference.

Determination of minerals

Mineral contents (calcium, magnesium, sodium, potassium, iron copper, zinc and manganese) were determined according to the standard methods of the Association of Official Analytical Chemists AOAC [2005] using an atomic absorption spectrometer (Varian 220FS Spectr AA, Les Ulis, France). The sample was ashed at 550°C and the ash was boiled with 10 mL of 20% HCl in a beaker and then filtered into a 100 mL standard flask. Phosphorus was determined colorimetrically using the vanado molybdate method [AOAC, 1999]. All samples were analysed in triplicate.

Determination of amino acids

Amino acid composition was determined after hydrolysis of the samples by 6N HCl at 110°C for 24 h in vacuum sealed glass tubes according to Davies & Thomas [1973]. The sulphur-containing amino acids were oxidised using performic acid before 6N HCl hydrolysis. The amino acid analysis of the hydrolysed samples was then carried out by ion-exchange chromatography on a Biochrom 30 automatic amino acid analyzer (Biochrom Ltd, Cambridge, G.B.) according to

Spackman *et al.* [1958] using lithium citrate buffers as eluents and ninhydrin post-column reaction system. The period of an analysis lasted for 76 min for each sample. The column flow rate was 0.50 mL/min at 60°C with reproducibility within ±3%. The amino acids were identified and quantified by comparing peak profiles of the products with standard amino acid profiles. Amino acid standards were purchased from Sigma–Aldrich (St. Louis, MO, USA). All values were reported as means of three replicate determinations on mg/g crude protein of dry weight basis. Tryptophan was not determined.

Evaluation of protein quality (Amino acid score)

The quality of dietary protein was measured by finding the ratio of available amino acids in the protein concentrate compared with needs expressed as a ratio.

Amino acid score = mg of essential amino acid per g of test protein / mg of the same essential amino acid per g of protein in requirement pattern x100.

The requirement pattern suggested by the FAO/WHO/UNU [2007] for 1–2 year old children was used for this purpose.

Statistical analysis

All analyses were performed in three replications. Data on the composition of pap samples were analysed by one-way analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS 16.0 version). Differences between samples were tested according to Tukey test and considered to be significant at p < 0.05.

RESULTS AND DISCUSSION

Description of recipes

A total of 5 varieties of pap commonly consumed were collected. The local names, forms of the dish, ingredients and their proportions as well as the scientific names of the basic ingredients are listed (Table 1). Paps commonly consumed in Maroua were prepared from rice flour (*Gari marori*); maize flour (*Gari massardji*); yellow millet flour (*Gari karal*); white millet flour (*Gari mouscouari*) and red millet flour (*Gari digari*). Roasted peanuts paste, sugar, lemon juice and raw cow's milk were added during the preparation of these paps.

TABLE 1. List of the five varieties of pap most frequently consumed in the city of Maroua.

Local name of the pap	Forms of the pap	Ingredients (%)	Scientific names of the basic ingredients
Gari marori	Thick liquid	Rice flour (6.21), roasted peanuts paste (5.18), lemon juice (1.09), water (77.68), sugar (7.77), raw cow's milk (0.78), rice grains / boiled maize grains (1.29)	Oryza sativa, Arachis hypogea
Gari massardji	Thick liquid	Maize flour (6.65), roasted peanuts paste (4.69), water (78.19), sugar (7.82), lemon juice (1.09), raw cow's milk (0.58) rice grains / boiled maize grains (0.98)	Zea mays, Arachis hypogea
Gari karal	Thick liquid	Yellow millet flour (6.19), roasted peanuts paste (5.16), water (77.40), sugar (7.74), lemon juice (1.44), raw cow's milk (0.77), rice grains / boiled maize grains (0.98)	Pennisetum glaucum, Arachis hypogea
Gari mouscouari	Thick liquid	White millet flour (6.21), roasted peanuts paste (5.18), water (77.68), sugar (7.77), lemon juice (1.09), raw cow's milk (0.78), rice grains / boiled maize grains (1.29)	Digitaria exilis, Arachis hypogea
Gari digari	Thick liquid	Red millet flour (6.20), roasted peanuts paste (5.16), water (77.40), sugar (7.74), lemon juice (1.44), raw cow's milk (0.77), rice grains / boiled maize grains (1.29)	Digitaria iburua, Arachis hypogea

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TABLE 2. Proximate composition of pap.

Parameters	Gari marori n= 6	Gari massardji n= 6	<i>Gari karal</i> n= 6	Gari mouscouari n= 6	<i>Gari digari</i> n= 6
Moisture (g/100 g FW)	82.10±2.10 ^c	84.17±3.32 ^b	$83.42 \pm .1.50^{d}$	86.85±1.81 ^a	83.61±4.20°
Ash (g/100 g DM)	0.83 ± 0.21^{e}	1.24±0.31 ^b	1.35 ± 0.42^a	$1.16 \pm 0.36^{\circ}$	0.98 ± 0.20^{d}
Protein (g/100 g DM)	8.91 ± 0.53^{e}	9.61 ± 1.2^{d}	13.69 ± 1.4^{a}	$9.75 \pm 1.48^{\circ}$	11.59±0.94 ^b
Lipid (g/100 g DM)	4.07 ± 1.1^{d}	5.67 ± 0.9^{a}	4.20 ± 0.98 ^{cd}	4.80 ± 1.09^{b}	4.60 ± 1.3^{bc}
Crude fibre (g/100 g DM)	$0.90 \pm 0.07^{\rm b}$	1.32 ± 0.04^{a}	1.30 ± 0.05^a	1.04 ± 0.09^{b}	1.14 ± 0.03^{ab}
Carbohydrate (g/100 g DM)	85.29 ± 6.71^a	82.17±6.56°	79.47±5.42°	83.25±3.6 ^b	81.70 ± 4.26^{d}

Data presented as the mean \pm standard deviation of paps sampled in different households; Mean values with different superscript letters in the same row are significantly different (p< 0.05). FW: fresh weight; DM: dry matter.

TABLE 3. Protein, lipid, crude fibre and carbohydrate contents (g/100 g FW) and their contribution of dietary reference intakes (%) of children of 1–2 years old.

Parameters	DRI* (g/day)	Gari marori (%)	Gari massardji (%)	Gari karal (%)	Gari mouscouari (%)	Gari digari (%)
Protein	13	1.59 (12.27)	1.52 (11.70)	2.27 (17.46)	1.28 (9.86)	1.90 (14.61)
Lipid	30	0.73 (2.43)	0.90 (2.99)	0.70 (2.32)	0.63 (2.10)	0.75 (2.51)
Crude fibre	19	0.16 (0.85)	0.21 (1.10)	0.22 (1.13)	0.14 (0.72)	0.19 (0.98)
Carbohydrate	130	15.27 (11.74)	13.01 (10.01)	13.18 (10.14)	10.95 (8.42)	13.39 (10.30)

^{*}Dietary reference intakes (DRI) established by the Food and Nutrition Board of the National Research Council (NRC), [2005]. Values given are for children aged 1–2 years. FW: Fresh weight.

Preparation of pap

Gari marori (rice pap): The sieved rice flour was mixed with the roasted peanut paste and then mixed with water. The mixture was sifted through a sieve with very fine mesh again. Few rice grains or boiled maize grains were added to the mixture which was placed in the fire and stirred constantly until boiling. The raw cow's milk and sugar were added. The mixture was left still 3 min late on fire. The pap was then removed from the fire and lemon juice was added.

Gari massardji (corn pap): It was prepared like Gari marori (rice pap) except that sieved rice flour was replaced by maize flour.

Gari karal (yellow millet pap): It was prepared like *Gari marori* (rice pap) except that sieved rice flour was replaced by yellow millet flour.

Gari mouscouari (white millet pap): It was prepared like *Gari marori* (rice pap) except that sieved rice flour was replaced by white millet flour.

Gari digari (red millet pap): It was prepared like *Gari ma-rori* (rice pap) except that sieved rice flour was replaced by red millet flour.

Proximate composition

Proximate composition of pap is shown in Table 2. The parameters determined were moisture, ash, protein, lipid, crude fibre and carbohydrate. Moisture contents of pap samples ranged between 82.10 (*Gari marori*) and 86.85 g/100 g FW (*Gari mouscouari*) and differed significantly (p<0.05). Moisture content is an index of water activity of many foods. High moisture content of the sample may reduce the energy and nutrient densi-

ties of the pap. These values were higher than moisture content (77.29 g/100 g FW) in pap consumed in Ngor-Okpala, Local Government Area of Imo state of Nigeria [Ukegbu & Anyika, 2012]. Moisture contents range of pap samples were slightly lower than 87.4 g/100 g FW found in *Akamu*, pap consumed in Nsukka situated in the North of Enugu State of Nigeria [Okeke & Eze, 2006]. FAO [2001] reported that staple foods such as maize, millet and sorghum are high in starch and as such, absorb a lot of water during cooking which makes them bulky.

Ash contents of pap samples ranged from 0.83 to 1.35 g/100 g DM. The lowest ash content was obtained from *Gari marori* while the highest was obtained from *Gari karal*. The values of the ash contents of samples collected were significantly different (p<0.05). The ash content of a food is a determinant of the mineral content of that particular food. The ash contents of pap varieties studied were higher than those of 0.75 g/100 g DM reported by Ukegbu & Anyika [2012] in pap consumed in Ngor-Okpala, Local Government Area of Imo state of Nigeria.

Protein contents of pap samples varied from 8.91 for *Gari marori* to 13.69 g/100 g DM for *Gari karal* and were significantly different (*p*<0.05). The protein contents of these paps were higher than protein contents of 7.88 and 6.76 g/100g DM reported by Amigo *et al.* [2010] respectively in maize and millet pap consumed in North Western of Nigeria. These values were also higher than the protein content of 2.22 in yellow pap and 4.48 g/100 g DM in sorghum pap eaten in Nasarawa State of Nigeria [Makanju & Awogbanja, 2012]. The higher protein content of pap samples studied was due to addition of raw cow's milk and roasted peanuts paste. Ponka *et al.*

TABLE 4. Mineral composition (mg/100 g DM) of pap.

Minerals	Gari marori n=6	Gari massardji n=6	<i>Gari karal</i> n=6	Gari mouscouari n=6	Gari digari n=6
Ca	$30.25 \pm 0.80^{\circ}$	40.59 ± 0.75^{d}	$77.75 \pm 0.49^{\text{b}}$	89.98 ± 0.82^{a}	$76.50 \pm 0.74^{\circ}$
Mg	$50.75 \pm 1.54^{\circ}$	80.56 ± 2.53^{a}	72.50 ± 2.09 ^b	80.60 ± 1.24^{a}	49.35 ± 1.51^{d}
P	$141.8 \pm 3.02^{\circ}$	231 ± 2.27^{a}	188.5 ± 2.49^{b}	189.5±3.13 ^b	137.5 ± 2.45^{d}
Na	12.40 ± 1.23^{b}	$6.40 \pm 2.40^{\circ}$	12.50 ± 1.78^{b}	25.77 ± 2.38^{a}	4.75 ± 0.90^{d}
K	$211.25 \pm 7.53^{\circ}$	322.22 ± 6.55^{a}	203.75 ± 3.43^{d}	291.20 ± 3.07^{b}	198.20±5.58°
Fe	$4.31 \pm .0.72^{\circ}$	$4.29\pm0.92^{\circ}$	3.35 ± 0.57^{d}	$4.47 \pm 0,46^{b}$	6.25 ± 0.93^a
Zn	0.87 ± 0.08^{cd}	1.07 ± 0.02^{bc}	1.83 ± 0.61^a	1.20 ± 0.50^{b}	0.75 ± 0.43^{d}
Cu	0.17 ± 0.08^a	0.17 ± 0.02^a	0.40 ± 0.05^a	0.21 ± 0.08^a	0.30 ± 0.02^a
Mn	$0.76 \pm 0.01^{\circ}$	0.64 ± 0.01^{d}	1.07 ± 0.04^a	0.85 ± 0.02^{b}	$0.75 \pm 0.03^{\circ}$

Data presented as the mean \pm standard deviation of paps sampled in different households; Mean values with different superscript letters in the same row are significantly different (p < 0.05). DM: Dry matter.

TABLE 5. Mineral content (mg/100 g FW) and its contribution in dietary reference intakes (%) of 1–2 year old children.

Minerals	DRI* (mg/day)	Gari marori (%)	Gari massardji (%)	Gari karal (%)	Gari mouscouari (%)	Gari digari (%)
Ca	500	5.41 (1.08)	6.43 (1.28)	12.89 (2.58)	11.83 (2.37)	12.54 (2.51)
Mg	80	9.08 (11.36)	12.75 (15.94)	12.02 (15.03)	10.60 (13.25)	8.09 (10.11)
P	460	25.38 (5.52)	36.57 (7.95)	31.25 (6.79)	24.92 (5.42)	22.54 (4.90)
Na	1000	2.22 (0.22)	1.01 (0.10)	2.07 (0.21)	3.39 (0.34)	0.78 (0.08)
K	3000	37.81 (1.26)	51.01 (1.70)	33.78 (1.13)	38.29 (1.28)	32.48 (1.08)
Fe	7	0.77 (11.02)	0.68 (9.70)	0.56 (7.93)	0.59 (8.40)	1.02 (14.63)
Zn	3	0.16 (5.19)	0.17 (5.65)	0.30 (10.11)	0.16 (5.26)	0.12 (4.10)
Cu	0.34	0.03 (8.95)	0.03 (7.92)	0.07 (19.51)	0.03 (8.12)	0.05 (14.46)
Mn	1.2	0.14 (11.34)	0.10 (8.44)	0.18 (14.78)	0.11 (9.31)	0.12 (10.24)

^{*}Dietary reference intakes (DRI) established by the Food and Nutrition Board of the Institute of Medicine (IOM) [2000, 2001, & 2004]. Values given are for children aged 1–2 years. FM: Fresh weight.

[2006] reported that roasted peanuts paste was a good source of protein (35.76 g/100 g DM).

Lipid contents of pap samples ranged from 4.07 in *Gari marori* to 5.67 g/100 g DM in *Gari massardji* and were significantly different (*p*<0.05). The lipid contents of pap samples studied were higher than 2.94 g/100 g DM reported by Okeke & Eze [2006] in *Akamu*, pap consumed in Nsukka situated in the North of Enugu state of Nigeria. Roasted peanuts paste is one of the basic ingredients in pap preparation increasing the lipid content of pap studied.

Crude fibre contents of pap ranged from 0.90 for *Gari marrori* to 1.32 g/100 g DM for *Gari massardji*. The crude fibre contents were similar for *Gari marori* and *Gari mouscouri*, and also for *Gari massardji* and *Gari karal*. The crude fibre contents of all the pap varieties were lower than the recommended (5 g/100 g) proposed by FAO/WHO [1985].

Carbohydrate contents of pap ranged between 79.47 for *Gari karal* to 85.29 g/100 g DM for *Gari marori*. The values of the carbohydrate content in the pap collected were significantly different (p<0.05). The carbohydrate contents

of pap were higher than carbohydrate content of 76.71 g 100 g DM in pap consumed in Ngor-Okpala Local Government Area of Imo State of Nigeria [Ukegbu & Anyika, 2012] and 73.52 g/100 g DM found in *Akamu*, pap consumed in Nsukka situated in the North of Enugu state of Nigeria [Okeke & Eze, 2006], but lower than carbohydrate content of 95.98 g/100 g DM found in pap consumed in Ngor-Okpala, Local Government Area of Imo state of Nigeria [Ukegbu & Anyika, 2012] and 90.89 g/100 g DM found in maize pap consumed in North western of Nigeria [Anigo *et al.*, 2010].

Protein, lipid, crude fibre and carbohydrate contents (g/100 g FW) and their contribution of dietary reference intakes (%) of 1–2 year old children are presented in the Table 3. Consumption of 100 g of each pap would meet 9.86–17.46%, 2.10–2.99%, 0.72–1.13% and 8.42–11.74% of the Dietary reference intakes respectively for protein, lipid, crude fibre and carbohydrate.

Mineral content

Results given in Table 4 show the mineral contents of pap samples. P and K could be considered as the major minerals

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TABLE 6. Amino acids composition (mg/g protein) of pap.

Amino acids	Gari marori n=6	Gari massardji n=6	Gari karal n=6	Gari mouscouari n=6	Gari digari n=6			
Essential amino acids								
His	18.29±1.01 ^d	21.02 ± 1.05^{a}	18.77±1.05°	18.87±1.06 ^b	15.10±1.02°			
Thr	29.63 ± 1.03^{b}	27.37 ± 1.13^{d}	$28.20 \pm 1.08^{\circ}$	32.10 ± 1.09^{a}	24.85±1.01°			
Val	41.64±1.01°	42.46±1.11 ^b	41.49 ± 1.14^{d}	43.38±1.11 ^a	36.07±1.01°			
Met	$1.46 \pm .0.01^{d}$	2.08±0.01°	2.85 ± 0.04^{a}	2.46 ± 0.03^{b}	0.86 ± 0.02^{e}			
Ile	31.76 ± 1.02^{d}	$33.09 \pm 1.09^{\circ}$	33.82 ± 1.06 ^b	34.77 ± 1.09^a	28.21±1.01°			
Leu	63.75 ± 1.02^{d}	70.76±1.21°	75.68 ± 1.28^{a}	72.41 ± 1.22^{b}	63.24 ± 1.04^{e}			
Phe	44.89 ± 1.00^{d}	48.70 ± 1.13^{a}	$46.02 \pm 1.15^{\circ}$	46.56 ± 1.13^{b}	42.80 ± 1.02^{e}			
Lys	20.65±1.01 ^b	$20.40 \pm 1.06^{\circ}$	18.77 ± 1.02^{d}	21.23 ± 1.06^{a}	11.73±1.01°			
TEAA	252.08 ± 18.97	265.87 ± 20.88	265.60 ± 22.04	271.79±21.09	222.86±19.65			
		Non-essentia	l amino acids					
Asp	92.82±1.01 ^b	99.90±1.25a	91.75±1.16°	90.15±1.29 ^d	91.80±1.07°			
Glu	162.74 ± 1.04^{e}	179.60±1.58 ^b	172.90±1.67°	182.05 ± 1.64^{a}	163.93 ± 1.36^{d}			
Ser	$39.84 \pm 1.02^{\circ}$	42.98 ± 1.20^{a}	39.44 ± 1.10^{d}	41.33 ± 1.12^{b}	33.99 ± 1.02^{e}			
Gly	50.51 ± 1.15 ^b	52.24±1.12a	$44.41 \pm 1.09^{\circ}$	42.67 ± 1.16^{e}	44.26 ± 1.03^{d}			
Arg	77.78 ± 1.02^{b}	78.77 ± 1.28^a	$72.32 \pm 1.26^{\circ}$	70.77 ± 1.22^{d}	$58.50 \pm 1.06^{\circ}$			
Ala	41.86 ± 1.02^{d}	46.10±1.11 ^b	47.48 ± 1.15^{a}	43.08±1.11°	39.34±1.01°			
Pro	39.17 ± 1.04^{e}	$48.39 \pm 1.10^{\circ}$	51.42 ± 1.08 ^b	52.10±1.20 ^a	40.03 ± 1.02^{d}			
Tyr	31.43 ± 1.02^{b}	27.37±1.16°	32.58 ± 1.21^a	31.18±1.13°	28.13 ± 1.01^{d}			
Cys	5.39 ± 0.02^{e}	7.39 ± 0.03^{b}	7.96 ± 0.03^{a}	5.95 ± 0.07^{d}	$6.30 \pm 0.06^{\circ}$			
TNEAA	541.53 ± 46.11	582.73 ± 50.69	560.26±47.72	559.28 ± 50.78	506.30 ± 46.55			
TAA	793.60	848.60	825.86	831.08	729.16			
ΣΤΕΑΑ / ΣΤΑΑ (%)	31.76	31.33	32.16	32.70	30.56			

Data presented as the mean \pm standard deviation of paps sampled in different households; Mean values with different superscript letters in the same row are significantly different (p<0.05); His: Histidine; Thr: Threonine; Val: Valine; Met: Methionine; Ile: Isoleucine; Leu: Leucine; Phe: Phenylalanine; Lys: Lysine; Asp: Aspartic acid; Glu: Glutamic acid; Ser: Serine; Gly: Glycine; Arg: Arginine; Ala: Alanine; Pro: Proline; Tyr: Tyrosine; Cys: Cysteine; TEAA: Total Essential amino acids; TNEAA: Total Non-Essential Amino Acids; TAA: Total amino acids.

in all pap samples. P and K contents ranged from 137.5 (*Gari digari*) to 231 mg/100 g DM (*Gari massardji*) and 198.20 (*Gari digari*) to 322.22 mg/100 g DM (*Gari massardji*) respectively. Other minerals and their concentrations in pap were as follows: Ca, 30.25 (*Gari marori*) to 89.98 mg/100 g DM (*Gari mouscouari*); Mg, 49.35 (*Gari digari*) to 80.60 mg/100 g DM (*Gari mouscouari*); Na, 4.75 (*Gari digari*) to 25.77 mg/100 g DM (*Gari mouscouari*); Fe, 3.35 (*Gari karal*) to 6.25 mg/100 g DM (*Gari digari*); Zn, 0.75 (*Gari digari*) to 1.83 mg/100 g DM (*Gari karal*) and Mn, 0.64 (*Gari massardji*) to 1.07 mg/100 g DM (*Gari karal*). Cu was the least abundant mineral element in pap with concentration range of 0.17 (*Gari massardji*) to 0.30 mg/100 g DM (*Gari digari*). Significant difference (*p*<0.05) was observed in the distribution of Ca, Mg, P, Na, K, Fe, Zn and Mn in pap except Cu.

K contents of pap samples (198.20–322.22 mg/100 g DM) were higher than the K content of 57.36 mg/100 g DM found in maize pap of Jos Plateau of Nigeria [Solomon

et al., 2000]. The K contents of pap samples were however closer to K content of 217 mg/100 g DM found in maize pap of North Western Nigeria [Anigo et al., 2010]. Furthermore, P contents of 137.5 to 231 mg/100 g DM in pap were higher than the P content of 91 mg/100g DM found in millet pap and 92 mg/100 g DM found in maize pap of North Western Nigeria [Anigo et al., 2010]. Ca contents of pap samples (30.25-89.98 mg/100 g DM) were higher than the Ca content of 18.98 mg/100 g DM found in maize pap of Imo State of Nigeria [Ukegbu & Anyika, 2012]. Moreover, Mg contents of pap (49.35–80.56 mg/100 g DM) were higher than the Mg content of 23.7 mg/100 g DM found in maize pap of Jos Plateau of Nigeria [Solomon et al., 2000]. Na contents of pap samples (4.75–25.77 mg/100 g DM) were higher than the Na content of 1.1 mg/100 g DM found in maize pap of Imo State of Nigeria [Ukegbu & Anyika, 2012]. Fe contents of pap samples (3.35–6.25 mg/100 g DM) were higher than the Fe content of 2.49 mg/100 g DW found in maize pap of Umua-

TABLE 7. Essential amino acids composition (mg/g protein)	of pap compared to FAO/WHO/UNU [2007] reference pattern suggested for 1–2 year
old children (mg/g protein).	

Amino acids	Gari marori n=6	Gari massardji n=6	<i>Gari karal</i> n=6	Gari mouscouari n=6	Gari digari n=6	FAO/WHO/UNU (2007) 1–2 years old
His	18.29	21.02	18.77	18.87	15.10	18
Thr	29.63	27.37	28.20	32.10	24.85	27
Val	41.64	42.46	41.49	43.38	36.07	41
Met+Cys	6.85	9.47	10.81	8.41	7.16	25
Ile	31.76	33.09	33.82	34.77	28.21	31
Leu	63.75	70.76	75.68	72.41	63.24	63
Phe+Tyr	76.32	76.07	78.60	77.74	70.93	46
Lys	20.65	20.40	18.77	21.23	11.73	52

His: Histidine; Thr: Threonine; Val: Valine; Met+Cys: Methionine+Cysteine; Ile: Isoleucine; Leu: Leucine; Phe+Tyr: Phenylalanine+ Tyrosine; Lys: Lysine.

TABLE 8. Amino acid score (%) of pap based on the essential amino acid content and the pattern for 1–2 year old children by FAO/WHO/UNU [2007].

Amino acids	Gari marori n=6	Gari massardji n=6	Gari karal n=6	Gari mouscouari n=6	<i>Gari digari</i> n=6
His	101.61	116.78	104.28	104.83	83.89
Thr	109.74	101.37	104.44	118.89	92.04
Val	101.56	103.56	101.20	105.80	87.98
Met+Cys	27.40a	37.88 ^a	43.24 ^b	33.64^{a}	28.64 ^b
Ile	102.45	106.74	109.10	112.16	91.00
Leu	101.19	112.32	120.13	114.94	100.38
Phe+Tyr	165.91	165.37	170.87	169.00	154.20
Lys	39.71 ^b	39.23 ^b	36.10^{a}	40.83 ^b	22.56a

His: Histidine; Thr: Threonine; Val: Valine; Met+Cys: Methionine+Cysteine; Ile: Isoleucine; Leu: Leucine; Phe+Tyr: Phenylalanine+ Tyrosine; Lys: Lysine, a= First limiting amino acid; b= Second limiting amino acid.

hia Abia state of Nigeria [Henry-Unaeze, 2011]. Zn contents of pap samples (0.75–1.83 mg/100 g DM) were lower than the Zn content of 2.49 mg/100 g DM found in maize pap consumed in Nigeria [Ogbonnaya et al., 2012]. Mn found in this study (0.64–1.07 mg/100 g DM) was lower than the Mn content of 1.97 mg/100 g DM in millet pap consumed in North Western Nigeria [Anigo et al., 2010]. These values were also lower than the Mn content of 4.41 mg/100 g DM of maize pap of Jos Plateau of Nigeria [Solomon et al., 2000]. Cu contents of pap samples (0.17–0.30 mg/100 g DM) were lower than 2.52 mg/100 g DM found of maize pap of Jos Plateau of Nigeria [Solomon et al., 2000].

Earlier research on humans and livestock has shown that optimal intakes of elements such as Na, K, Mg, Ca, Mn, Cu, and Zn can reduce individual risk factors for health problems such as cardiovascular disease [Sanchez-Castillo *et al.*, 1998]. These elements take part in neurochemical transmission and also serve as constituents of biological molecules, as cofactors for various enzymes and in variety of different metabolic processes [Mayer & Vyklicky, 1989]. Phosphorus plays a central role in metabolism and is a major structural component of bones and teeth [Ajayi *et al.*, 2006].

The mineral contents (mg/100 g FW) and their contribution of dietary reference intakes (%) of children of 1–2 years old are presented in Table 5. Consumption of 100 g of each pap would meet 1.08–2.28%, 10.11–15.94%, 4.90–7.95%, 0.08–0.34%, 1.08–1.70%, 7.93–14,63%, 4.10–10.11%, 7.92–19.51% and 9.31–14.78% of the Dietary reference intakes respectively for Ca, Mg, P, Na, K, Fe, Zn, Cu and Mn.

Amino acid profile

Table 6 shows the amino acid profiles of pap samples. A significant difference (p<0.05) was observed in the distribution of all amino acids among all pap samples. Leucine was the most abundantly occurring essential amino acid in the pap studied while glutamic acid was the most abundantly occurring amino acid in all samples tested. This amino acid profile was similar to that of maize pap of Jos Plateau of Nigeria reported by Solomon *et al.* [2000]. All essential amino acids are found to be present in all the pap samples investigated except tryptophan, which was not determined. The human body does not synthesize the essential amino acids that need to be provided from food. Deficiency in these amino acids may lead to susceptibility of humans to infectious diseases

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[Peng et al., 2007]. Essential amino acids represented less than 33% of total amino acids in all sample which, according to Blankership & Alford [1983], indicated an unbalance between amino acids.

Essential amino acid composition (mg/g protein) of pap compared to FAO/WHO/UNU [2007] reference pattern suggested for children of 1–2 years old in mg/g protein

The proteins are considered nutritive if their essential amino acids profiles are higher than the reference levels required by at least children (1–2 years old that need the most of these amino acids). As compared with the FAO/WHO/UNU [2007] recommendation for 1–2 years old children (Table 7), histidine, threonine, valine, isoleucine and phenylalanine + tyrosine in all pap samples met the recommended children requirement (18, 27, 41, 31 and 46 mg/g protein, respectively) except in *Gari digari*. Methionine+cysteine and lysine in all pap samples were under the recommended children requirement (25 and 52 mg/g protein, respectively). Leucine in all pap samples met the recommended children requirement (63 mg/g protein). Leucine activates the mammalian target of rapamycin to stimulate protein synthesis and inhibit intracellular proteolysis [Dillon, 2013].

Amino acid score (%) of pap based on the essential amino acid content and the pattern for 1-2 year old children acc. to FAO/WHO/UNU [2007]

Table 8 shows the amino acid scores (%) for the dishes analysed in this study based on the essential amino acid content and the pattern for children 1–2 years old of the FAO/WHO/UNU [2007] recommendation. As expected, methionine + cysteine were the first limiting amino acids in all pap samples except in *Gari karal* and *Gari digari* followed by lysine. On the other hand, lysine was found to be the first limiting amino acid in *Gari karal* and *Gari digari* followed by methionine + cysteine. These observations were in agreement with a previous report of lysine being the second limiting amino in maize pap consumed on Jos Plateau of Nigeria [Solomon *et al.*, 2000].

CONCLUSIONS

We have provided the nutritional composition of five varieties of pap commonly consumed in Maroua, city of the Far--North Region of Cameroon. The results suggest that these pap samples were found to contain a higher concentration of carbohydrate. Appreciable levels of minerals and amino acids were recorded in all the pap varieties. Consumption of each pap (100 g) by 1-2 year old children would meet 9.86-17.46% and 0.08-19.51% of their daily recommended intake for protein and minerals, respectively. Essential amino acid in most of these pap samples met the recommended children requirement of the FAO/WHO/UNU for 1-2 years old children except methionine+cysteine. But, methionine + cysteine and lysine were the limiting essential amino acids in these samples. This up-to-date and culturally appropriate information will contribute to the calculation of accurate energy and nutrient intakes for the Maroua population.

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