

Nutritional, Phytochemical and Antioxidant Evaluation of Some Cameroonian Traditional Bean Based Dishes: Potential Functional Relevance for Oxidative Stress-Related Diseases

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Abstract

Malnutrition in urban areas is associated with the emergence of non communicable nutritional diseases (diabetes, cardiovascular diseases and cancers), which are becoming an increasingly serious public health problem. Poor cooking practices and a lack of knowledge about foods rich in bioactive compounds, such as legumes, significantly reduce the nutrient intake from food. Therefore, this study aimed to evaluate the nutritional, phytochemical and antioxidant properties of the ready to eat traditional bean based dishes commonly consumed in Cameroon. After a survey of 415 households, nine bean based dishes were collected, representing three dishes per recipe among the most frequently used recipes. The proximate and mineral contents, phytochemical profile and antioxidant activities of the collected dishes were determined. Stir-fried beans were the most commonly consumed culinary preparation by 271 (65.30%) persons. The most common ingredient, depending on the spices used, was ginger 138 (33.25%). The protein, carbohydrate and fat content varied from 20.41% - 27.77%, 23.28% - 34.36%, and 21.99% - 33.89%, respectively. Minerals ranged from 89.10 - 100.16 mg/100 g DW, 1.99 - 3.25 mg/100 g DW, 62.10 - 92.40 mg/100 g DW, and 245 - 289 mg/100g DW for calcium, zinc, magnesium, and phosphorus, respectively. The recipes also had a total phenolic content (TPC) ranging from 388.26 - 592.25 mg GAE/100 g DW, alkaloid content ranging from 27.44 - 50.08 mg Qu/100 g DW and flavonoid content ranging from 46.38

- 152.29 mg QE/100 g DW and ferric reducing antioxidant power (FRAP) from 7.72 - 12.59 mg Fe²⁺/100 g. These traditional bean based dishes could have relevant functional potential for diseases related to oxidative stress. However, it would be interesting to improve, optimise and standardise the treatment and cooking methods for better exploitation.

Keywords

Bean Based Recipes, Cooking Methods, Antioxydant Compounds, Nutrient Contents, Cameroon

1. Introduction

An unhealthy diet is one of the main risk factors associated with the development of numerous chronic, non-communicable diseases. It generally manifests as inappropriate eating habits [1]. The dietary practices of populations have a central place within advances in food technology and nutrition. In light of the food-related issues of the present day, examining the dietary habits of populations is a vital approach to alleviating malnutrition. Most foods consumed by humans undergo technological processing, as is the case with legumes. Legumes are an important food group in the human diet due to their nutritional properties, low cost, and health benefits [2]. Beans can partially substitute meat in the diet, particularly when consumed alongside other legumes [3]. Beans are among the most widely consumed legumes worldwide, alongside soybeans and peanuts [4].

The common bean (*Phaseolus vulgaris* L.) is a herbaceous plant belonging to the *Fabaceae* family. There are different varieties which can be distinguished by the shape, colour and size of the seeds [5]. It is an important source of minerals (iron, magnesium, zinc, calcium and potassium), protein (22.5 g/100 g dry matter), carbohydrates (46.1 g/100 g dry matter), fibre (15.1 g/100 g dry matter), but contains little fat (1.5 g/100 g dry matter) [6]. It also contains thiamine, riboflavin, niacin, vitamin B6 and vitamin B9, which act as coenzymes for lipid, carbohydrate and protein metabolism [7]. Like most plants, beans are a rich source of phytochemical compounds such as phenolic compounds (flavonoids, tannins). The investigation of their chemopreventive properties has shown great potential in combating chronic metabolic diseases [8]. In Cameroon, the red variety mainly cultivar DOR-701 is the most consumed in various culinary forms each requiring different preparation techniques.

Depending on the region (North, South, West and East), dietary habits and lifestyle, cooking practices of beans are constantly changing, which can sometimes degrade or alter their nutritional properties. Beans are consumed in various ways in Cameroon, such as stir-fried beans, beans mashed with plantain or potatoes “*pilé*” and stir-fried beans with corn, also known as “*corn-chaff*”. These dishes are produced using a variety of preparation techniques, which can vary in terms of the type and quantity of ingredients used, as well as cooking times. These varia-

tions in cooking methods therefore influence the final quality of the dish obtained, in terms of both nutrition and therapeutic value. However, previous studies undertook on the enhancement and improvement of bean quality focused much more on the raw or pre-processed (roasted, sprouted, fermented) forms [9] [10], with very few carried out on the ready to eat dishes. Since beans are not consumed in their pre-processed form, it would be interesting to assess the nutritional, phytochemical and antioxidant content of the ready to eat bean based dishes.

2. Materials and Methods

2.1. Design and Sampling Procedures

The protocol for this study was approved by the Regional Ethics Committee for Research in Human Health and signed consent was obtained from the households taking part in the study. A previous study conducted by Mananga *et al.* [9] revealed that tomatoes, onions, garlic, leeks and refined palm oil were the major common ingredients used in the preparation of stir fried bean. However, the main difference lay in the use of spices. An investigation (using a questionnaire) into food was conducted to determine the most consumed stir fried bean based dishes, the quantity and different types of ingredients used in the preparation of these recipes (Table 1) during July to October 2023. The sample size of the population was estimated using Open Epi 3.01, with the assumption of a 50% frequency of household who cook bean based dishes in the target study site, with a 5% margin of error, 95% confidence level. Adding 10% for incomplete data or biases observed in this study. Therefore, the estimated sample size was 422 households.

Table 1. Description of the spices and ingredients content of the main bean based dishes.

Spices	Dishes	Ingredients	Cooking time (minutes)
Ginger, green anise, clove	Dish 1 (D1)	Bean (500 g), tomato (250.2 g); bell pepper (42.3 g); leek (85 g); onion (225 g); Garlic (45.6 g); green condiments (32g); ginger (18.9 g); green aniseed (0.1 g); clove (0.1 g); salt (3 g); refined palm oil (250 ml)	33
	Dish 3 (D3)	Bean (500 g), tomato (190 g); bell pepper (33.2 g); leek (41.8 g); onion (95.7); garlic (14.5 g); green condiments (35.3 g); ginger (20.9 g); green aniseed (0.5 g); clove (0.6 g); salt (2.8 g); refined palm oil (300 ml)	22
	Dish 9 (D9)	Bean (500 g), tomato (438.8 g); bell pepper (72.1 g); leek (71.3 g); onion (372.7); garlic (38.2 g); green condiments (17.6 g); ginger (47.8 g); green aniseed (0.1 g); clove (0.6 g); salt (3.3 g); refined palm oil (365 ml)	27
Ginger, white pepper	Dish 4 (D4)	Bean (500 g), tomato (416.4 g); bell pepper (48.8 g); leek (178.7 g); onion (176.2); garlic (20.9 g); green condiments (23.3 g); ginger (35 g); white pepper (3.1 g); salt (3.1 g); refined palm oil (250 ml)	27
	Dish 5 (D5)	Bean (500 g), tomato (378.3 g); bell pepper (44.4 g); leek (143 g); onion (136); garlic (36.3 g); green condiments (34.9 g); ginger (18.3 g); white pepper (4.5 g); salt (3 g); refined palm oil (350 ml)	23

Continued

	Dish 6 (D6)	Bean (500 g), tomato (446.8 g); bell pepper (48.1 g); leek (57.6 g); onion (164); garlic (23.5 g); green condiments (45.1 g); ginger (42.7 g); white pepper (4.9 g); salt (3.5 g); refined palm oil (130 ml)	58
	Dish 2 (D2)	Bean (500 g), tomato (88.6 g); leek (73 g); onion (60); garlic (116 g); green condiments (43.7 g); ginger (35.8 g); salt (3.3 g); refined palm oil (250 ml)	30
Ginger	Dish 7 (D7)	Bean (500 g), tomato (362.7 g); leek (59.9 g); onion (140.2); garlic (11.4 g); ginger (47.8 g); salt (3 g); refined palm oil (230 ml)	29
	Dish 8 (D8)	Bean (500 g), tomato (441.1 g); bell pepper (19.3); leek (97 g); onion (152.3); garlic (6 g); green condiments (30.7 g); ginger (14.2 g); salt (3 g); refined palm oil (300 ml)	30

2.2. Preparation of the Dishes and Collection

The red bean seeds (DOR-701) were obtained from the Institute of Agricultural Research for Development (IRAD) in Foubot, Cameroon. Based on data from a food survey, we categorised households into 18 groups according to the spices they used to prepare stir-fried beans. After pre-treating the beans (by soaking them for eight hours and then boiling them for one hour), samples of beans were provided to each household according to their dietary habits. Appointments were scheduled with the households to observe the cooking process, note the cooking times, identify and collect the ingredients used and weigh the quantities.

The three most commonly used methods of cooking stir-fried beans were recorded. Chopped vegetables and fruit were added at the beginning of the cooking process, while spices were incorporated midway through. The cooking time ranged from 22 to 58 minutes depending on the household and the type of fuel used (butane or a wood fire). After cooking, the different recipes based on the spices used were collected from each group of households, and the ingredients used to prepare bean-based dishes were weighed. Nine recipes were collected from households: three using ginger alone as a spice; three using ginger, green aniseed and cloves as spices; and three using ginger and white pepper as spices.

After collecting the bean-based dishes, each meal was cooled to room temperature. Equal proportions of each dish were then homogenised using a Vevor blender. Aliquots were used to determine the moisture content [11]. Samples of the dried meals were packed in polyethylene bags, properly closed, and stored in a deep freezer at -20°C for further analysis (Figure 1).



Dish 1 (D1)



Dish 2 (D2)



Dish 3 (D3)

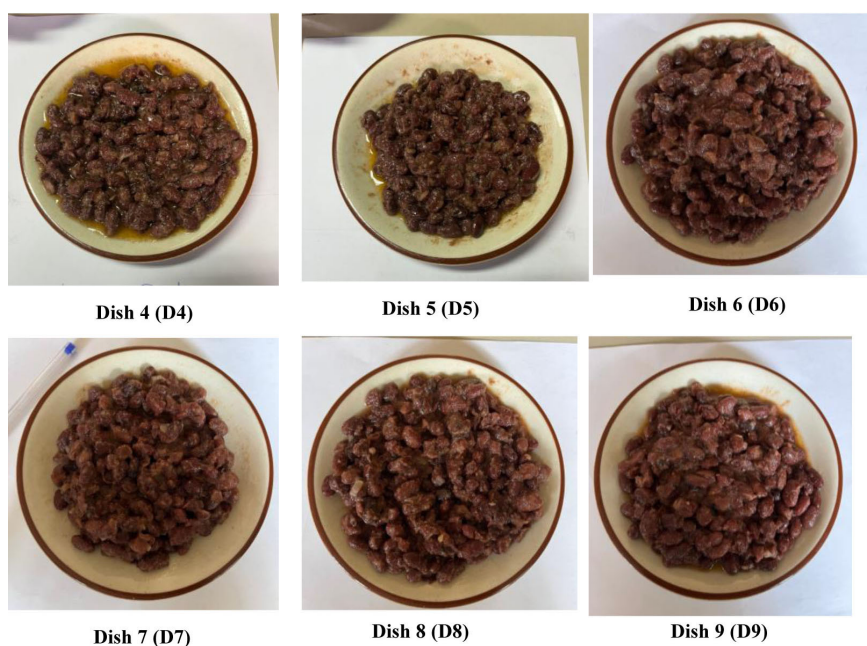


Figure 1. Stir-fried beans based dishes collected from households.

2.3. Analyses

2.3.1. Proximate and Mineral Analyses

The moisture, protein, fat, fibre, ashes, carbohydrates and mineral contents of bean dishes were assessed using the standard methods as recommended by the AOAC [11]. The energy value (E) per 100g of dry weight was obtained according to the formula: $E = (9 \times \% \text{ fat}) + (4 \times \% \text{ protein}) + (4 \times \% \text{ carbohydrate})$ [12].

2.3.2. Determination of β -Carotene Contents

The β -carotene content was determined using the method described by Ranganna [13]. The β -carotene was determined by soaking 1 g of the sample in 5 ml of methanol for 2 h at room temperature under dark conditions in order to get a complete extraction. The β -carotene layer was separated using hexane solvent. The absorbance was read at 436 nm. The beta carotene content was calculated using the following formula: $\beta\text{-carotene (mg/100g)} = \text{OD (436 nm)} \times V \times D \times 100 \times 100/W \times Y$ (with V = Total volume of extract; D = Dilution factor; W = Sample weight; Y = Percentage dry weight content of the sample).

2.3.3. Extraction of Phytochemical Tests and Antioxidant Activities

The extraction of phytochemical molecules was carried out by maceration. A precise mass of 1 g of each sample was placed in an Erlenmeyer flask with 30 ml of hydroalcoholic solution (70% ethanol). The mixture was subjected to constant agitation for 30 minutes, protected from light and at room temperature, and then the supernatant was separated from the residue by filtration. To ensure complete extraction, the residue underwent two additional successive extractions under the same conditions but with reduced solvent volumes (10 ml). The three filtrates obtained were then combined in a 50 ml volumetric flask, and the volume was ad-

justed to the mark with 70% ethanol.

2.3.4. Determination of Total Phenolic Compounds

The antioxidant capacity has been evaluated by means of the total phenolic and total flavonoid contents (TPC and TFC respectively). The determination of total phenolic compounds (TPC) was done by the Folin-Ciocalteu method using Gallic acid as a standard with slight modifications [14]. Approximately 2 mL of the extract solution of each sample was mixed with 2 mL of Folin Ciocalteu reagent 2 N for 1 min. After reacting for 5 min, 2 mL of 10 % of Na₂CO₃ solution was added and the mixture was vortexed vigorously and kept at room temperature in a dark environment for 15 min. The absorbance was measured at 760 nm. The TPC was calculated using a standard curve of the standard gallic acid (concentrations ranging from 20 to 200 µg/mL) and the result was expressed as mg Gallic acid equivalents (GAE)/100 g dry weight (DW) of the sample (mg GAE/100 g DW).

2.3.5. Determination of Total Flavonoid Contents (TFC)

The total flavonoid content was evaluated using the method described by Dhar *et al.* [14] with minor modifications. The TFC was determined using a standard curve of quercetin and expressed as mg quercetin equivalents (QE)/100 g dry weight (DW) of the sample (mg QE/100 g DW).

2.3.6. Determination of Total Tannin Contents

The determination of total tannin was carried out using the method described by Burns [15]. About 1 ml aliquot of supernatant was taken and mixed with 5 ml of vanillin-HCl reagent prepared by combining an equal volume of 8% concentrated HCl in methanol and 4% vanillin in methanol. The resulting mixture was incubated at ambient temperature (25°C) for 20 minutes and D-catechin was used as a standard. The total tannin content was evaluated in mg equivalent of catechin/100 g dry weight (DW) of the sample using the calibration curve.

2.3.7. Determination of Total Alkaloid Contents

Total alkaloid contents were determined by iron chloride and hydrogen chloride methods as described by Singh *et al.* [16] and the values were expressed as mg quinin equivalents (QuE/100 g dry weight (DW)) of the sample (mg QuE/100 g DW).

2.3.8. Determination of *in Vitro* Antioxidant Activity

1) Total antioxidant capacity

The antioxidant capacity of dishes was assessed using the method of Prieto *et al.* [17]. In each test tube, it was successively introduced 50 µL of each extract solution and 200 µL of reagent solution (0.6 M sulfuric acid, 28 mM of sodium phosphate and 4 mM of ammonium molybdate). Tubes were capped with beads and heated to 95°C for 90 min, then cooled. Absorbance of the blue staining mixture was measured at 695 nm. Total antioxidant capacity was expressed as mg gallic

acid equivalent/100 g DW sample.

2) Ferric Reducing Antioxidant Power test (FRAP)

The FRAP assay was performed according to the method described by Benzie and Strain [18] with minor modifications. The extract solution of 100 μL was mixed with 3 mL of FRAP reagent and incubated in a dark room for 5 min. The absorbance of the solution was determined at 593 nm. Ferric reducing antioxidant power was expressed as mg of Fe^{2+} equivalent/100 g dry weight (DW) of the sample using the calibration curve of Fe^{2+} .

3) Anti free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH)

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical capacity of the different extracts was determined following the methods described by Lopes-Lutz *et al.* [19] with slight modifications. In test tubes, 150 μL of samples were added at different concentrations 1.5% 1.25%; 1%; 0.75% and 0.5%. Then, 3.9 mL of DPPH solution (1.0 mM in 70% aqueous methanol) was added and incubated for 60 min in the dark at room temperature. The inhibition (%) was calculated by the following equation: Inhibition = (absorbance of control – absorbance of sample/absorbance of control) * 100.

The IC₅₀ (mg/ml) is the concentration of the antioxidant that traps 50% of free radicals. It was obtained by performing a nonlinear regression on a graph showing the trapping percentage as a function of concentration.

2.4. Statistical Analyses

The obtained data of the sample were presented as mean $\pm$ standard deviation (SD) of nine samples with three replicates per dish. Different data were analyzed by one way analysis of variance (ANOVA). IBM SPSS statistics version 25.0 was used for data analysis. Differences between samples were tested according to Tukey's test at $p < 0.05$.

3. Results and Discussion

3.1. Consumption of Bean Based Dishes

Overall, 415 questionnaires were validated for analysis, with 7 being ignored due to incomplete or incoherent information. **Figure 2** shows the frequency of consumption of different bean dishes. Of those surveyed, 333 (80.24%) had a preference for ready-to-eat bean dishes. Of these, 271 (65.30%) preferred fried beans, 54 (13.01%) preferred pounded beans, and 14 (3.37%) preferred corn chaff. Of all the people surveyed, 78 (18.79%) had no particular preference for a bean-based dish. Beans can be prepared in various ways, with the addition of several ingredients, which also influences the cooking time. These different preparation methods can significantly affect the final nutritional and functional quality of the food. This finding is consistent with that reported by Rossi [20], who found that bean consumption varies according to cultural identity and ethnic origin, with significant differences between cultural groups.

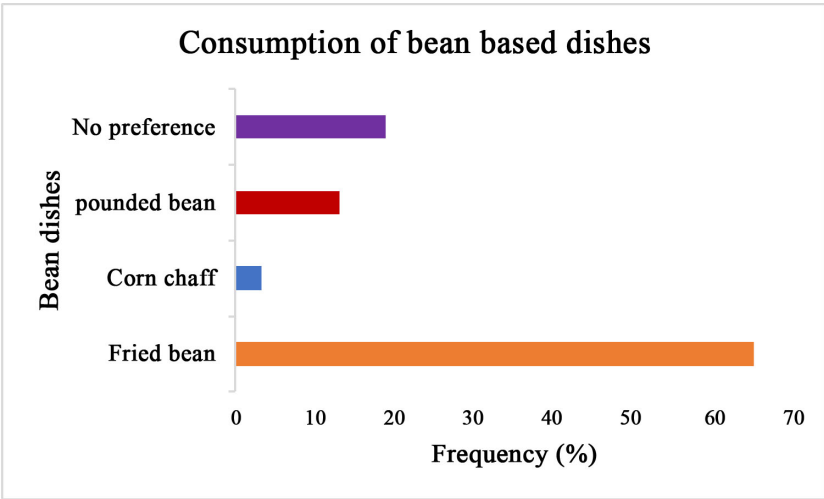


Figure 2. Frequency of consumption of the different bean based dishes.

3.2. Bean Based Dishes Description and Cooking Methods

Table 2 lists the most commonly consumed spices. These spices were collected according to the various preparation methods and combinations used in households. Eighteen (18) techniques for cooking stir-fried beans were identified. The results showed that 138 households (33.25%) used ginger as their only spice; 65 households (15.66%) used ginger combined with white pepper; and 57 households (13.73%) used ginger combined with green aniseed and cloves. The choice of spices by consumers could be justified by their flavour, smell, availability at the time of the study and their very pronounced aroma. These findings are consistent with those of Fritts *et al.* [21], who demonstrated that moderate additions of dried herbs and spices significantly increased liking and preference for most vegetables compared to oil and salt alone.

Table 2. Methods for cooking stir fried beans according to the spices used.

	Spices used	Frequency n (%)
1	Ginger	138 (33.25)
2	White pepper, ginger	65 (15.66)
3	Green aniseed, clove, ginger	57 (13.73)
4	Clove, ginger, white pepper	16 (3.85)
5	Green aniseed, 4 cotés, white pepper, ginger	8 (1.92)
6	Clove	3 (0.72)
7	Ginger, white pepper, rondelle spice	5 (1.20)
8	Ginger, rondelle spice	3 (0.72)
9	White pepper, ginger, pèpè spice	5 (1.20)
10	Clove, ginger	24 (5.78)
11	White pepper, rondelle spice	5 (1.20)

Continued

12	Green aniseed, ginger, pèpè spice	3 (0.72)
13	Ginger, rondelle spice, pèpè spice	5 (1.20)
14	Nkoti spice, ginger	3 (0.72)
15	No spices	16 (3.85)
16	Green aniseed, clove, ginger, white pepper	22 (5.30)
17	White pepper	16 (3.85)
18	Green aniseed, ginger	22 (5.30)

3.3. Proximate Chemical Composition per 100 g Edible Portion of Bean Based Dishes

The moisture content of the bean based dishes raised significantly from 63.94 (D9) to 65.57 (D2) g/100 g of fresh weight of bean based dishes. The amount of moisture in the recipes is dependent on the type of dish and also the amount of water used in the preparation. The moisture content was lower compared to the value (71 g/100 g edible portion) found by Ponka *et al.* [22] in *Koki* (traditional dish) prepared from crushed cowpea and palm oil and consumed in Cameroon. But higher than the moisture content of 61.5 g/100 g edible portion recorded by Ponka *et al.* [22] in *Ekomba* (traditional dish) prepared from maize flour with roasted peanut paste. Fat, total protein, crude fiber, carbohydrate and ash contents of the bean based dishes are shown in **Table 3**. The total protein values expressed in g/100 g DW varied from 20.41 (D3) to 27.77 (D2). The dishes are good sources of protein, however a significance difference ($p < 0.05$) was observed between the protein contents of all the bean based dishes. This could be due to the fact that beans already contain 20 to 25% protein based on their dry weight content [9]. The protein content of the bean based dishes is higher than those of other beans seed such as *Lima* bean-benniseed food 8.33%, *Lima* bean prorridge 8.30% DW [23]. These dishes can be used to improve proteins intake in high risk protein energetic malnutrition in preschool children. Fat ranged in g/100 g DW from 21.99 (M6) to 33.89 (D9). The higher fat content observed in the samples is due to poor knowledge of the recommendations regarding good feeding where population add a big quantity of hot red palm oil. Many studies highlight the fact that, the oil absorption capacity of a plant-based product is defined by a foods component's ability to trap oil, which influences the techno-functional protudiesperties of the final product. Complex carbohydrates primarily cause oil absorption [24]. Additionally, the use of large quantities of cooking oils tends to increase the proportion of fats relative to other macronutrients, such as proteins and carbohydrates. As legumes are an important source of carbohydrates and proteins, they have a high oil absorption capacity [25]. Most dishes with basic protein and carbohydrate content had higher oil intake during cooking. This was the case for D3, D5, D8 and D9, which had the highest cooking oil intake. The high level of oil in the dishes could contribute to increasing the prevalence of metabolic disorders. Crude fiber contents varied in g/100 g DW from 5.10 (D9) to 8.07 (D3). The high rate of crude fiber

could be explain by the fact that beans are naturally rich in dietary fiber. In addition, the cell walls of legumes contain polysaccharides, which constitute insoluble and soluble fibre [26]. The increase in fibre content in these dishes is very important for health because the consumption of fiber-rich food is associated with a reduce risk of developing heart diseases, rectal and colon cancer, diabetes [27]. Ash contents ranged in g/100 g DW from 5.10 (D9) to 8.08 (D4). Carbohydrate levels ranged from 23.28 (D3) to 34.36 g/100 g DW (D8). This low carbohydrate contents in bean based dishes make these dishes a good source of meal for people with metabolic disorders (diabetes, hypertension). The carbohydrate contents of the bean based dishes is lower compared to the value (62.05 g/100 g edible portion) found by Kana *et al.* [28] in cassava stew prepared from cassava, manioc, onion, dried fish, herbs and garlic, and value (39,4 g/100 g edible portion) found by Sharma *et al.* [29] in *Fufu* corn. The energy content in the samples ranged from 401.75 for D6 to 523.65 kcal/100 g for D9 and was significantly different ($p < 0.05$). The energy content of the samples were higher than the value of 87 and 185 Kcal/100 g edible portion of “*pomme pilées*” and “*Etondo salé*” respectively found by Kouebou *et al.* [30] and consumed in Cameroon.

Table 3. Proximate composition of bean based dishes (g/100 g).

Parameters	Bean based dishes								
	D1	D2	D3	D4	D5	D6	D7	D8	D9
Water content g/100 g fresh weight	64.51 ± 0.01 ^c	65.57 ± 0.00 ^f	65.21 ± 0.01 ^e	63.98 ± 0.00 ^a	64.72 ± 0.03 ^d	64.95 ± 0.00 ^c	64.34 ± 0.00 ^b	64.75 ± 0.00 ^d	63.94 ± 0.02 ^a
Protein (g/100 g DW)	27.15 ± 0.03 ^g	27.77 ± 0.04 ^h	20.41 ± 0.05 ^a	23.26 ± 0.07 ^f	21.85 ± 0.05 ^d	22.79 ± 0.07 ^e	27.31 ± 0.07 ^g	21.48 ± 0.05 ^c	20.61 ± 0.04 ^b
Carbohydrate (g/100 g DW)	33.26 ± 0.19 ^e	30.40 ± 0.05 ^d	23.28 ± 0.96 ^a	29.17 ± 0.96 ^c	29.07 ± 0.14 ^c	28.17 ± 0.05 ^b	33.40 ± 0.05 ^e	34.36 ± 0.05 ^g	34.05 ± 0.05 ^f
Fat (g/100 g DW)	27.45 ± 0.40 ^b	30.47 ± 0.03 ^c	32.68 ± 0.88 ^d	28.35 ± 0.35 ^b	32.37 ± 0.32 ^d	21.99 ± 0.46 ^a	27.03 ± 0.03 ^b	32.69 ± 0.27 ^d	33.89 ± 0.57 ^d
Fiber (g/100 g DW)	6.16 ± 0.24 ^{bc}	6.81 ± 0.29 ^{cd}	8.07 ± 0.51 ^e	6.03 ± 0.01 ^{bc}	5.10 ± 0.10 ^a	8.00 ± 0.00 ^e	7.27 ± 0.00 ^{de}	5.44 ± 0.19 ^{ab}	6.55 ± 0.04 ^{cd}
Ash (g/100 g DW)	5.80 ± 0.05 ^{ab}	4.76 ± 0.10 ^a	5.91 ± 0.16 ^{ab}	8.08 ± 0.65 ^c	4.87 ± 0.14 ^a	5.43 ± 0.37 ^{ab}	6.21 ± 0.00 ^b	5.55 ± 0.54 ^{ab}	5.10 ± 0.29 ^{ab}
Energy (Kcal)	488.69	506.91	468.34	464.87	495.01	401.75	486.11	517.57	523.65

Mean values in a line having different superscript are significantly different at ($p < 0.05$). D1 - D9 = Dish 1 - Dish 9.

3.4. Mineral Contents of Bean Based Dishes

The results of mineral contents of bean based dishes in mg/100 g DW are presented in **Table 4**. Calcium, magnesium, phosphorus and zinc contents raised from 89.10 (D7) to 100.17 (D2), from 62.10 (D2) to 91.00 (D3), from 245.00 (D1, D3, D4) to 289.00 (D2) and 1.99 (D4) to 3.25 (D2) respectively. A significant difference was observed between the mineral contents of all the bean based dishes.

Calcium and phosphorus appeared to be the majors minerals in samples. Zinc was the least abundant mineral in the samples. Calcium and phosphorus contents were higher compared to those reported by Kouebou *et al.* [30] in Cameroonian dishes: “*Igname Malaxé*” and dried fish groundnut soup. Magnesium content in the samples was lower than the magnesium content of 120 mg/100 g edible portion found in groundnut-pudding consumed in Cameroon [30]. Furthermore, the zinc values obtained in the study are similar to those recorded by Kouebou *et al.* [30] in “*Banane Malaxée*”. According to FAO-WHO [31], it has been proved that zinc helps to strengthen the immune system which is important to speed up the healing process after cell damage. β -Carotene is a natural pigment belonging to the carotenoid family, it is an organic compounds found in many plant based foods. The levels observed in the bean dishes collected, expressed in mg/100 g DW, ranged from 0.51 (D1 and D7) to 1.11 (D8). A significance difference ($p < 0.05$) was observed between the β -carotene contents of all the bean based dishes. These significant differences could be due to variations in the quantities of ingredients used to make the dishes (tomatoes, red oil). Studies have indeed shown that these ingredients are excellent sources of provitamin A, and using them in ready-to-eat meals could further increase the concentration of β -carotene in these dishes [32].

Table 4. Mineral and β -carotene contents of bean based dishes (mg/100 g DW).

Parameters	Bean based dishes								
	D1	D2	D3	D4	D5	D6	D7	D8	D9
Ca	100.06 $\pm 1.40^b$	100.16 $\pm$ 4.29 ^b	100.01 $\pm$ 0.08 ^b	95.50 $\pm$ 2.68 ^{ab}	100.15 $\pm$ 2.84 ^b	100.10 $\pm$ 0.00 ^b	89.10 $\pm$ 0.14 ^a	100.06 $\pm$ 2.82 ^b	100.05 $\pm$ 0.14 ^b
Mg	82.00 $\pm$ 2.82 ^{de}	62.10 $\pm$ 0.70 ^a	91.00 $\pm$ 2.82 ^{ef}	69.40 $\pm$ 1.55 ^{abc}	74.00 $\pm$ 0.00 ^{bcd}	92.40 $\pm$ 4.24 ^f	77.90 $\pm$ 2.82 ^{cd}	65.50 $\pm$ 0.28 ^{ab}	83.60 $\pm$ 3.25 ^{def}
P	245.00 $\pm 14.14^a$	289.00 $\pm$ 0.00 ^b	245.00 $\pm$ 0.00 ^a	245.00 $\pm$ 11.31 ^a	257.00 $\pm$ 14.14 ^{ab}	271.00 $\pm$ 14.84 ^{ab}	270.00 $\pm$ 0.00 ^{ab}	275.00 $\pm$ 2.82 ^{ab}	275.00 $\pm$ 0.00 ^{ab}
Zn	2.64 $\pm$ 0.28 ^b	3.25 $\pm$ 0.21 ^c	2.40 $\pm$ 0.28 ^{ab}	1.99 $\pm$ 0.01 ^a	2.89 $\pm$ 0.14 ^{bc}	2.81 $\pm$ 0.00 ^{bc}	2.77 $\pm$ 0.14 ^{bc}	2.93 $\pm$ 0.49 ^{bc}	3.00 $\pm$ 0.21 ^{bc}
β-carotene	0.51 $\pm$ 0.00 ^a	0.53 $\pm$ 0.00 ^b	0.82 $\pm$ 0.00 ^f	0.64 $\pm$ 0.00 ^c	0.77 $\pm$ 0.00 ^e	0.74 $\pm$ 0.00 ^d	0.51 $\pm$ 0.00 ^a	1.11 $\pm$ 0.00 ^h	0.83 $\pm$ 0.00 ^g

Mean values in a line having different superscript are significantly different at ($p < 0.05$). D1 - D9 = Dish 1 - Dish 9.

3.5. Phytochemical Component and *in Vitro* Antioxidant Activity of Bean Based Dishes

Legumes are a good source of phenolic compounds and anthocyanins that exert an antioxidant effect, they directly neutralize reactive oxygen species and free radicals, reducing oxidative stress [33]. Total phenolic compounds (TPC), total flavonoids, tannins, alkaloids, ferric ion reducing antioxidant power (FRAP) and DPPH (%) inhibition ratio of bean based dishes were determined in water, ethanol 70% extracts (Table 5). Ethanolic extract revealed that the TPC in mg gallic acid /100 g DW was increased from 388.26 (D2) to 592.25 (D9). The TPC of the bean

based dishes was lower than that of other studies by Djuikwo *et al.* [34] (1170.40 mg EAG/100 g edible portion) in functional biscuits made of wheat flour and *Diospyros mespiliformis* pulp. The significance difference observed ($p < 0.05$) in the total phenolic compounds could be due to the quantities of the ingredients used to prepare these dishes. However, many authors have demonstrated the thermosensitivity of secondary metabolites, such as phenolic compounds. When exposed to high temperatures for prolonged periods, these compounds undergo biochemical mechanisms that lead their denaturation [27]. Total flavonoids compounds ranged from 46.38 (D7) to 152.29 (D4) mg CE/100 g DW. The flavonoids contents were higher compared to the value 11.87 mg as rutin equivalent (RE)/g of dried plant obtained in the Faba bean (*Vicia faba*) genotypes cultivated in Tunisia [35]. The TPC and TFC can be used as important indicators of the antioxidant capacity for any product that is intended to be considered as a natural source of antioxidants in functional foods [35]. Tannins are sometimes considered as antinutritional factor but their antioxidant activity at a certain threshold has been proven [36]. The presented tannin contents fluctuated between 308.79 (D5) to 537.50 mg Ca/100 g DW (D9). The lowest values of total alkaloids were observed in D2 (27.44 mgQu/100 g DW) and the highest values were observed in D5 (50.08 mgQu/100 g DW). Total antioxidant capacity varied from 23.06 (D2) to 45.54 mgAG/100 g DW (D4). The IC₅₀ values ranged from 2.49 (D2) to 3.55 mg/mL (D3). This result was higher than 45% of DPPH inhibition ratio of 1 g of dried beetroot pomace determined by Vodnar *et al.* [37]. FRAP of bean based dishes varied from 7.72 to 12.59 mg FeII/100 g DW for D2 and D4 respectively. These results are lowest compared to the values 61.1% - 66.4% and 69.5% - 74.3% for DPPH and FRAP respectively obtained in the Pinto and Black bean affected by thermal processing [38]. The current finding was in line with the finding of Swati *et al.* [39] observed the effects of cooking on the antioxidant capacities may differ depending on cooking method, localization of the structures and conditions (temperature, cooking time, portion, ingredients, presence of oxygen and water). In this study, the bean based dishes's antioxidant activities (DPPH, FRAP) decreased which was consistent with Silva *et al.* [40]. Optimising various cooking practices (ingredients, cooking time, pre-treatment methods) would improve the antioxidant potential of the stir fried bean based dish and could protect consumers from free radicals attacks.

Table 5. Bioactive components and antioxidant profile of bean based dishes.

Parameters	Bean based dishes								
	D1	D2	D3	D4	D5	D6	D7	D8	D9
TPC (mg GAE/100 g DW)	425.42 ± 4.54 ^b	388.26 ± 9.19 ^a	483.81 ± 7.98 ^{de}	585.43 ± 3.54 ^g	479.29 ± 8.61 ^{cd}	498.22 ± 2.27 ^{ef}	511.87 ± 4.54 ^f	465.61 ± 1.31 ^c	592.25 ± 1.31 ^g
Flavonoids (mg Q/100 g DW)	71.74 ± 1.64 ^{bc}	95.33 ± 0.84 ^d	70.52 ± 0.46 ^b	152.29 ± 0.62 ^h	133.71 ± 0.84 ^g	119.34 ± 0.93 ^f	46.38 ± 0.81 ^a	108.49 ± 0.93 ^e	73.91 ± 0.46 ^c

Continued

Tannins	358.21 ±	409.50 ±	387.77 ±	432.87 ±	308.79 ±	324.54 ±	336.45 ±	316.93 ±	537.50 ±
(mg CE/100 g DW)	13.13 ^{bc}	6.21 ^d	14.14 ^{cd}	11.16 ^d	11.31 ^a	14.17 ^{ab}	15.20 ^{ab}	13.66 ^{ab}	10.60 ^e
Total alkaloids	38.79 ±	27.44 ±	36.79 ±	31.64 ±	50.08 ±	43.54 ±	31.43 ±	33.67 ±	34.51 ±
(mg Qu/100 g DW)	3.13 ^{bc}	3.52 ^a	0.14 ^{bc}	0.34 ^{ab}	1.51 ^d	2.46 ^{cd}	1.96 ^{ab}	1.09 ^{ab}	0.08 ^{ab}
TAC	32.19 ±	23.06 ±	27.97 ±	45.54 ±	38.12 ±	42.54 ±	25.09 ±	38.68 ±	38.49 ±
(mg GAE/100 g DW)	0.15 ^d	0.09 ^a	0.08 ^c	0.08 ^b	0.09 ^e	0.05 ^g	0.08 ^b	0.09 ^f	0.08 ^f
IC₅₀ (mg/ml)	2.70 ±	2.49 ±	3.55 ±	3.03 ±	3.10 ±	2.95 ±	3.36 ±	3.15 ±	3.50 ±
	0.05 ^a	0.00 ^b	0.00 ^f	0.00 ^{cd}	0.00 ^d	0.00 ^c	0.00 ^e	0.12 ^d	0.01 ^f
FRAP (mg Fe II/100 g DW)	9.38 ±	7.72 ±	8.59 ±	12.59 ±	8.92 ±	8.52 ±	9.04 ±	8.47 ±	7.82 ±
	0.06 ^f	0.01 ^a	0.04 ^c	0.03 ^g	0.03 ^d	0.02 ^{bc}	0.01 ^e	0.02 ^b	0.03 ^a

Mean values in a line having different superscript are significantly different at ($p < 0.05$). D1 - D9 = Dish 1 - Dish 9; TPC = Total Phenolic Compounds; TAC = Total Antioxidant Capacity Q = Quercetin; CE = Catechin, Qu = Quinin; GA = Gallic acid; FeII = Iron.

4. Conclusion

The study found that stir fried bean based dishes are the most widely consumed and preferred forms of beans in many populations in Yaounde. Stir fried bean have good nutritional potential. The high protein levels in the stir fried bean make them have potential for infant formulation foods. However, all dishes contained a high amount of fat and a low quantity of β -carotene. They can be improved by appropriate cooking practices. These bean based dishes are rich in Ca, Mg, P and Zn which can cover the daily recommended needs for these minerals in all age groups. The cooking process has a significant effect on phenolic compounds (TPC, flavonoids, tannins, total alkaloids) and the antioxidant activity (TAC, DPPH, FRAP), for the nine bean based dishes analyzed. Therefore, optimising and standardized the various ingredients and preparation methods for these dishes would improve their phenolics compounds and antioxidant activity and could help to prevent diseases related to oxidative stress.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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