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Chemometric dissimilarity in nutritive value of popularly consumed Nigerian brown and white common beans

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ABSTRACT

Brown beans are the preferred varieties over the white beans in Nigeria due to their assumed richer nutrients. This study was aimed at assessing and characterising some popular Nigerian common beans for their nutritive value based on seed coat colour. Three varieties, each, of Nigerian brown and white beans, and one, each, of French bean and soybean were analysed for 19 nutrients. *Z*-statistics test showed that Nigerian beans are nutritionally analogous to French bean and soybean. Analysis of variance showed that seed coat colour varied with proximate nutrients, Ca, Fe, and Vit C. Chemometric analysis methods revealed superior beans for macro and micro nutrients and presented clearer groupings among the beans for seed coat colour. The study estimated a moderate genetic distance (GD) that will facilitate transfer of useful genes and intercrossing among the beans. It also offers an opportunity to integrate French bean and soybean into genetic improvement programs in Nigerian common beans.

1. Introduction

Common bean, *Phaseolus vulgaris*, belongs to the Family Papilionaceae, order, Leguminosae – Fabaceae. Its common names are common bean, haricot beans, kidney beans and navy beans (English); haricot commun and haricot (French) (Wortmann, 2006). Its local names in Nigeria are "èwà" (Yoruba), "wanke" (Hausa) and "agwa" (Igbo). Regular seed coat colour found among the common bean seeds are brown, black, light brown, red, white; and sometimes with specks. Common bean is independently originated in both Central and South America and spread to other parts of the world (Chacon, Pickersgill, & Debouck, 2005). The mature dry seeds of common bean are consume widely as a pulse and most often serves as cheaper sources of dietary proteins and starch, compare to meat, fish, and poultry. Common bean was formerly tag as the "meat of the poor", but today, it is much valued as a light compliment and flavour to various carbohydrate-based meals (Iqbal, Khalil, Ateeq, & Khan, 2006; Wortmann, 2006).

In tropical Africa, common bean is primarily produced and consumed as a pulse, its seeds are boiled with seasoning and some added oil (Tharanathan & Mahadevamma, 2003). In southwest Nigeria, common bean is used to prepare varieties of recipe such as beans pulse, beans paste, beans cake and also as a compliment to carbohydrate-based foods, like rice, maize, and plantain to add varieties to meals. Its pulse is taking with bread, fried plantain or pap (corn paste). Reported health benefits associated with common bean consumption include reduction of cholesterol level and coronary heart diseases, prevention of colon cancer, and decreased diabetes (Anderson, Smith, & Washnock, 1999; Tharanathan & Mahadevamma, 2003).

There are two main categories of popularly consumed common bean in Nigeria, the brown and the white beans, and are differentiated further based on seed sizes and colour intensity. The popular brown common beans are, small brown, big light brown, and big brown while white beans are small white, small white with brown pecks (pecked white) and big white. The brown beans are the preferred varieties, due to their assumed sensorial properties such as softening, good taste and aroma on cooking, most especially, the big light brown. Currently, white beans are no longer in consumer preference list, and hence, are quickly vanishing from Nigerian markets, which results into their cheaper prices when compared to brown beans.

With increasing global population and a larger proportion is expected from both Africa and Asia by year 2020 (Pinstrup-Anderson, Pandya-Lorch, & Rosegrant, 1999), there will be need for increasing food security and protein sources, of which common bean will be playing a vital and substantial role. Furthermore, there is need for additional sources of minerals and vitamins, to achieve improved health of the populace, especially, in children and pregnant women. Therefore, the present study was designed to assess the nutritive values of some popular Nigerian common beans as

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alternative sources of protein with combined starch, micronutrients and vitamins. In addition, to provide better information on comparative nutritive analysis of Nigerian brown and white common beans based on seed coat colour. Furthermore, the beans were characterised using chemometric methods to identify superior beans for nutrients. This would provide useful information on the nutritive value of Nigerian common beans, help breeders in proper selection for important desirable nutrients, and at large, promote utilisation of common beans in Nigeria.

2. Materials and methods

2.1. Bean samples collection and preparation

Three varieties, each, of brown and white beans that are commonly consumed in Nigeria were selected for the study, a variety of green French bean and soybean samples were included as comparative controls. The seeds of the bean samples were obtained from three different retailers at different areas (as replicates) in popular national Bodija market, Ibadan, Oyo State, Nigeria. Ten grams of wholesome seeds were handpicked from the lots of each sample materials, rinsed thrice in de-ionised water, dried in an air-circulating oven at 65 °C for 5 h, and ground in a sample attrition mill (model No. ED-5). The powdered samples were sieve into 1 mm particle sizes, repacked and kept at 4 °C.

2.2. Assay methods

All chemical analyses were carried out in triplicates at the Chemistry Department Laboratory, Tai Solarin University of Education, Ijagun, Ogun State Nigeria, using modified methods of AOAC (2005). Moisture content (MC) was determined by oven dried 10.0 g of 1 mm particle size samples at 65 °C to a constant weight. To obtain ash content, 0.5 g of 1 mm particle size of beans samples were combusted at 500 °C for 4 h in a cool muffle furnace, cool to room temperature, weighed and kept at 4 °C for further use.

2.2.1. Macronutrient analysis

Crude protein content of the bean flour samples was estimated based on micro Kjeldahl method (percentage total of $N \times 6.25$) using Kjeltec 2300 machine. The crude fat was extracted in petroleum ether using Soxhlet extractor at 40–60 °C. Crude fibre content was by stepwise digestion of 1.0 g fat-free dry matter in a mixture of H_2SO_4/NaOH, the residue was oven dried at 105 °C, cooled at 55 °C for 2 h and weighed. The total carbohydrate was estimated by difference.

2.2.2. Elemental analysis

A half gram ash of each sample was, subsequently, digested in 2.5 ml selenium/H_2SO_4 mixture (3.5 g Se/1 L H_2SO_4) at 200 °C and then, in 3 ml of H_2O_2 at 330 °C. The residue was re-suspended in selenium/H_2SO_4 mixture; Na, Mg, Ca, and K were determined using Jenway Digital Flame Photometer (PFP7 model) while Fe, Mn, Cu, and Zn were determined using Buck Scientific Atomic Absorption Spectrophotometer (BUCK 210VGP model).

2.2.3. Vitamin analysis

Five water soluble vitamins, Vits C, B_1 (thiamine), B_2 (riboflavin), B_3 (niacin), and B_6, were extracted from 2 g of freshly homogenised flour sample of the beans using an acid mix containing 2% metaphosphoric acid/8% acetic acid. Stock solution of the vitamins was prepared by dissolving 1 mg/ml of pure vitamin in the same acid mix. Internal standard (IStd) consisting of 10 μg/ml acetonitrile, was also prepared in the acid mix. Calibration standards were prepared with the acid mix at 5 levels, 0.2 μg/ml, 0.4 μg/ml, 0.6 μg/ml, 0.8 μg/ml, and 1.0 μg/ml. Each calibration standard and sample was spiked using 0.6 μg/ml IStd. Separation was achieved on a reverse phase High Performance Liquid Chromatography (Hewlett Packard 1100 series) using single pump, manual-sampler, and a C_{18} column (4.6 × 150 mm, 5 μm particle). Elution is by universal isocratic solvent of an organic mobile phase composition of hexane/isopropanol (98.5:1.5 v/v), at a flow rate of 1.5 ml/min, pressure range, 21–22 mPA, and temperature of 25 °C; detection of all vitamins in a sample were compromised at 325 nm.

2.3. Statistical analysis

Collected data was subjected to estimation of precision measures, analysis of variance (ANOVA) and Pearson correlation, to detect variation of nutrients with seed coat colour and relationships among the nutrients, respectively, using the statistical analysis system software package (SAS Institute Inc., 2002). Nutrient richness among the beans is evaluated by one-tailed *Z*TEST that estimates the probability if group mean (x) is greater than the observed population mean (μ_0), that is $x > \mu_0$, using excel sheet. The beans were characterised based on their nutrient composition using chemometric methods of principal components, cluster and canonical correlation analyses in the same SAS package. Genetic distance matrix between a pair of beans was generated by chi-square count method and hierarchical clustering of un-weighted pair grouping method of arithmetic was used for visualised presentation of groupings using dissimilarity analysis representative for Window software (DARwin, Perrier & Jacquemoud-Collet, 2006).

3. Results and discussion

3.1. Nutritive value of Nigerian common beans, French bean and soybean

The estimate of precision measures such as means and standard deviation (SD) across the eight varieties of bean for the 19 assessed nutrients is provided in Table 1.

Table 1
The overall precision measures for macronutrients, minerals and vitamins among eight popularly consumed bean samples in Nigeria.

Nutrients	Mean	Std dev	SE (±)	CV	Range	Min.	Max.
Macronutrients (g/100 g)							
MC	9.9	2.11	0.53	21.31	6.73	7.81	14.54
Ash	7.03	5.38	1.35	76.52	16.84	2.15	18.99
Protein	27.76	7.11	1.78	25.61	21.58	22.64	44.22
COH	44.79	16.67	4.17	37.23	48.64	11.96	60.6
Fat	5.55	5.38	1.34	96.96	16.66	2.3	18.96
Fibre	4.6	2	0.5	43.42	5.18	3.2	8.38
Macro-minerals (g/100 g)							
Ca	0.2	0.08	0.02	41.25	0.22	0.1	0.32
Mg	0.3	0.67	0.17	226.52	1.92	0.03	1.95
K	0.12	0.06	0.01	48.81	0.15	0.01	0.16
Na	0.03	0.01	0	23.29	0.03	0.02	0.05
Micro-minerals (mg/kg)							
Mn	14.6	17.82	4.46	122.1	54.6	5.4	60
Fe	121.44	28.62	7.16	23.57	83.54	82.8	166.34
Cu	7.28	2.52	0.63	34.64	7.74	5.16	12.9
Zn	26.63	8.41	2.1	31.58	28.6	16.88	45.48
Vitamins (mg/kg)							
Vit. C	76.95	11.98	2.99	15.57	34.13	58.32	92.46
Vit. B_1	0.19	0.08	0.02	44.37	0.25	0.1	0.35
Vit. B_2^{ns}	0.36	0.15	0.04	42.31	0.5	0.14	0.64
Vit. B_3^{ns}	0.17	0.22	0.06	133.75	0.91	0.08	0.99
Vit. B_6^{ns}	0.61	0.1	0.02	15.94	0.4	0.36	0.76

ns, non significant.