

Comparison of Proximate Composition and Nutritional Qualities of Fifty-Three Cashew Accessions from Burkina Faso

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Abstract

Cashew cultivation is growing in Burkina Faso, but nut production remains low. Identification of high-performance plant material with known varietal characteristics is essential for breeding. This study consisted of physical-chemical and nutritional characterization of almonds from a core selection of 53 cashew accessions from Burkina Faso. Proximate composition included contents in water, lipids, carbohydrates, proteins, ash, cellulose using standard methods. Major constituents were lipids with an average level of 50.71% ± 4.07%, followed by carbohydrates and proteins with average levels of 21.18% ± 3.81% and 20.62% ± 1.58%, respectively. Average water, ash and cellulose levels were 4.56% ± 0.39%, 2.87% ± 0.27% and 4.61% ± 2.52%, respectively. The analysis of variability within accessions, based on physical and chemical parameters, identified 3 groups that differ in lipids, carbohydrates, proteins, cellulose and energy value. The first group containing 17 accessions of fat-rich cashews, average protein levels and very high energy values is more interesting for tree improvement programs.

Keywords

Anacardium occidentale L., Cashew, Composition, Accessions, Burkina Faso

1. Introduction

Cashew (*Anacardium occidentale* L.) is a nut plant native to the tropical region

of America, particularly in Brazil [1]. Its cultivation has developed spontaneously and naturally in South American countries [2], while in the tropics, especially in many parts of Africa and Asia [3] its presence is attributed to man. The tree is known by different names, caju in Portuguese, cashew in English, cajuil in Spanish or acajou in French [4]. Considered in the past as a forest species to combat erosion and desertification, the cashew tree is now recognized as offering socio-economic opportunities [5] thanks to its false fruit, composed of the apple and the nut.

Cashew cultivation was introduced in the 1960s in Burkina Faso, following the example of Côte d'Ivoire, Mali and Benin, by the services of the Centre Technique Forestier Tropical (CTFT) using seeds from Benin [6]. It has expanded with the increase in orchards, from 1000 ha in 1980 to over 255,000 ha of plantations in 2015 [7]. This increase is the result of the introduction of seedlings and seeds from various origins, as well as the implementation of numerous cashew development programs. In Burkina Faso, the cashew tree is mainly cultivated for its nuts. Worldwide production of raw cashew nuts is estimated to 3,396,680 tons with a cultivated area of 3,276,756 ha in 2019 [8]. Africa is the first largest producer and exporter of cashew nuts in the world with a production of 2334 405 tons accounting for more than 50% of production. West Africa production in 2019 was 1,696,417 tons. In Burkina Faso, recent data collection gave a production of 136,558 tons with a cultivated area of 130,011 ha [8]. This important production makes cashew the third agricultural export product of Burkina Faso after cotton and sesame, and amounts to about US\$90 million in business [9].

The socio-economic importance of cashew is linked to the development of its products in agri-food, pharmacology, cosmetics and its beneficial effects on health.

Nutritionally, cashew kernels are of interest for their high energy content, including lipids, proteins, essential fatty acids and some oligo-elements [5] [10].

Industrially, cashew products have many uses in biscuits, pastries, fortified foods, snack products, etc.

Regarding its beneficial effects, several epidemiological and clinical studies have reported nutritional benefits of cashew consumption in the prevention of cardiovascular disease [11], type 2 diabetes [12], gallstones [13], gallbladder removal [14] and colon cancer [15]. Like all oleaginous (oilseeds), almost three quarters of the total calories in cashew nuts are due to fat. The majority (60%) of this fat is in the form of monounsaturated fatty acids, a type of fat with beneficial effects on cardiovascular health [11] [16]. In addition, other studies have also shown that walnuts improve mental health [17], increase bone mineral density [18] and decrease the risk of depression [19]. Its long-term consumption was also associated with a reduced risk of weight gain and obesity [20]. This clearly shows the challenge to screen to identify the best cashew accession for commercial breeding purposes.

The cashew industry in Burkina Faso, like many other producing countries, is

faced with several challenges. These include the heterogeneity of production, low orchard yields, the high rate of atypical plants [21], the lack of knowledge of existing cashew varieties and the potential of their fruits and by-products, the insufficient number of improved seedlings, the low technological level of processing units [9], and the low marketability of end-products. In addition, despite being the third largest export, very little research has been done on cashew nuts in Burkina Faso.

The cashew tree is an allogamous species and therefore does not reproduce identically by sexual means from one generation to the next. Thus, the practice of creating orchards with nuts and seedlings from nurseries is at the root of the low productivity of the national cashew orchard. To remedy this, the national plant breeding institute of (INERA) has been working since 2011 on the selection of mother trees displaying exceptional performance to be used for the creation of the first cashew cultivars in Burkina Faso. These trees were reproduced by grafting and kept as a collection in the INERA/Farako Bâ and Banfora stations for the purpose of safeguarding genetic diversity on the one hand, and selection and varietal improvement on the other. Thus, kernels of agro-morphologically characterized 53 cashew accessions, were physicochemically analysed in order to identify the best accession for commercial breeding.

2. Materials and Methods

2.1. Plant Material

Plant material consisted of cashew nut samples from 53 agro-morphologically characterized accessions from the Institut de l'Environnement et de la Recherche Agricole (INERA). These nuts were collected in 2020 in nine departments of the two regions of Haut-Bassins and Cascades in Burkina Faso (**Table 1**).

Accessions from which the nuts are derived are the result of a mass selection process from a population of 820 ecotypes. Prospective surveys in 2011, 2014 and 2015 identified trees with exceptional production from producers and their perceptions. The identified trees in the three areas were 166, 255 and 399 ecotypes, respectively. Each identified tree was monitored for three years in its original environment, following an approach previously described [22]. A screening step based on threshold values of three main performance criteria was adopted. These are kernel content with a threshold value of at least 25%, average raw nut weight with a threshold of 6 g and total tree production with a threshold of at least 20 kg for trees younger than 10 years, at least 30 kg for trees between 10 and 14 years old and 40 kg for trees at least 15 years old. The collected data underwent a rank test that allowed to screen the collected material and to select the 53 accessions that met the three main criteria.

For each accession, 2 kg of cashew nuts were sampled from the current crop of the accession and stored in jute bags to be sent to the laboratory of the Department of Food Technology (DTA) of the Institute of Research in Applied Sciences and Technologies (IRSAT).

Table 1. Origins/area and years of collection of cashew accessions in 2020.

Regions	Provinces	Departement	Number of cashew accessions	Accession reference
Cascades		Sindou	18	ET01; ET55A ET17 to ET32
		Léraba		
		Ouéléni	1	ET42
		Loumana	1	ET43
		Dakoro	1	ET55B
		Soubakagniedougou	8	ET02 to ET05; ET54; ET55C; ET57
	Comoé	Mangodara	7	ET13; ET52; ET53; ET60; ET62; ET63; ET67
Haut-Bassins	Kéné Dougou	Banfora	4	ET06; ET14; ET15, ET16
		Orodara	7	ET07 to ET12; ET69
		Kangala	6	ET37; ET45 to ET50

The nuts were crushed into two halves using shears (cashew nut kernel cutter) and the shells were removed to obtain the kernel. These almonds were then separated from their skin, the thin protective membrane that surrounds them. The raw almonds prepared in this way for each sample were weighed and then ground using an electric grinder (KN 195 Knifetec™). The powder samples obtained were placed in polyethylene jars and stored in the refrigerator at 4 °C prior to analyses.

2.2. Determination of Physicochemical and Nutritional Characteristics

Moisture, fat, protein, ash and carbohydrates were determined according to official AOAC methods.

The moisture content of the samples was determined by differential weighing of a 5 g sample before and after oven drying at 105 °C for 12 h [23]. Ash content was determined by incinerating 5 g of sample in a muffle furnace (Nabertherm) at 550 °C for 4 hours, according to the international standard [24]. The fat content of the samples was determined by the Soxhlet extraction method according to the international standard [25] with hexane as solvent. The total protein content was determined by the Kjeldahl method according to the French standard [26]. The total sugar content of the samples was determined by the spectrometric method (Spectrophotometer UNI 002_FR I 200) using orcinol-sulphuric acid reagent (Montreuil and Spik, 1969). The absorbance of the samples was read at 510 nm with a Fibre residue (FR) was determined by the differential method

[27] using the formula: FR (%) = [100 – ash (%) – Proteins (%) – fats (%) – sugars (%)]. The potential energy value (E) was estimated using Atwater coefficients [28] formulas follow: E (Kcal/100g) = [carbohydrate content (%) × 4 (Kcal) + protein content (%) × 4 (Kcal) + fat content (%) × 9 (Kcal)].

2.3. Statistical Analyses

All physicochemical and nutritional analyses were performed in triplicate. The data were then subjected to an analysis of variance (ANOVA). The Fisher test at the 5% level was used to compare means. Statistically significant difference was indicated at $p < 0.05$. Hierarchical ascending classification was used to structure the variability on the basis of Euclidean distances and aggregation by Ward's method. A discriminant factor analysis was used to describe the cashew nut accession groups identified. Data processing and all statistical analyses were performed using XLSTAT BASIC + software (Addinsoft, 2016).

3. Results

3.1. Overall Physico-Chemical and Nutritional Composition of Cashew Accessions Kernels

There were highly significant differences ($P < 0.001$) within the 53 nut kernel samples for all physico-chemical and nutritional parameters (Table 2). Moisture contents are quite low ranging from 3.71% to 6.02%, with an average of $4.56\% \pm 0.39\%$. Ash contents varied from 2.06% to 3.51% with an average of $2.87\% \pm 0.27\%$. Concerning fiber, the diversity is greater within the accessions with contents ranging from 0.66% to 11.89%, with an average of $4.61\% \pm 2.52\%$. Levels of lipids in the nut kernels were ranging from 39.90% to 57.61% with an average of $50.71\% \pm 4.07\%$. Protein contents of the kernels ranged from 16.76% to 24.44% with an average of $20.62\% \pm 1.58\%$. The minimum and maximum values for carbohydrate content were 12.20% and 32.92% respectively, with an average of $21.18\% \pm 3.81\%$. The potential energetic values among accessions range from 557.86 to 673.68 Kcal/100g, with an average of 623.59 ± 27.00 Kcal/100g.

Table 2. Physico-chemical and nutritional characteristics of cashew kernels from Burkina Faso.

Characteristics	Moisture (%)	Ash (%)	Cellulose (%)	Fat (%)	Protein (%)	Carbohydrates (%)	Energy value (Kcal/100g)
Number of accessions	53	53	53	53	53	53	53
Mean ± SD	4.56 ± 0.39	2.87 ± 0.27	4.61 ± 2.52	50.71 ± 4.07	20.62 ± 1.58	21.18 ± 3.81	623.59 ± 27.00
Minimum value	3.71	2.06	0.66	39.90	16.76	12.20	557.86
Maximum value	6.02	3.51	11.89	57.61	24.44	32.92	673.68
Cv (%)	8.55	9.41	54.66	8.03	7.66	17.99	4.33
P-value*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

SD = standard deviation.

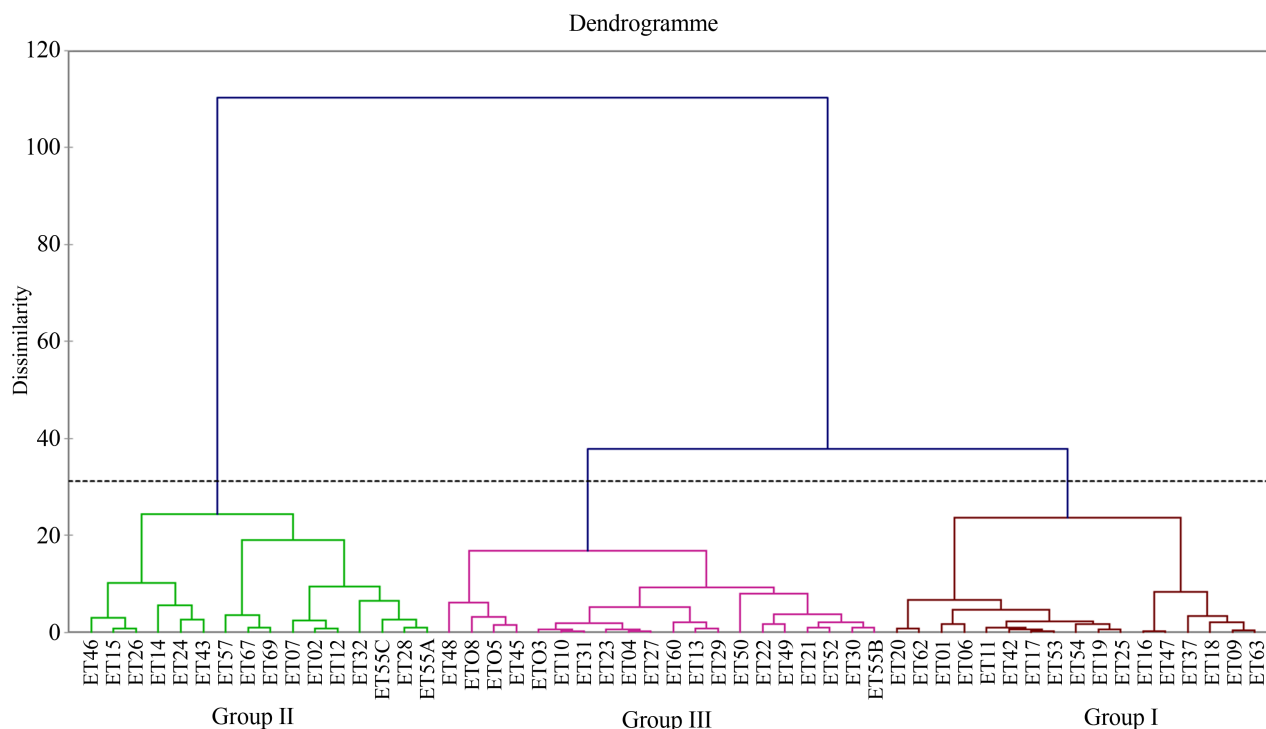


Figure 2. Ascending Hierarchical Classification (AHC) of the 53 accessions according to Ward's aggregation criteria.

of the AHC revealed a structuring of the variability of the accessions into three distinct groups. The variance decomposition shows that the inter-group variability corresponds to 82% against 18% for the intra-group variability. Comparison of the group means for the different variables in the discriminant factor analysis (DFA) revealed very highly significant differences for almost all variables with probability values (two-sided P-value) between 0.0001 and 0.008 (Table 3). The graphical representation of the half design of the discriminatory factor analysis (DFA) which explains 100% of the total variability among groups (Figure 3) together with the group means from the AHC shows a characterization of the groups as follows:

Group I, composed of 17 accessions, *i.e.* 32.07% of the total number of accessions, is made up of cashew accessions whose kernels have a high fat ($54.99\% \pm 1.51\%$ DM) and energy (648.54 ± 11.83 Kcal/100g) content, an average protein content ($20.44\% \pm 1.78\%$ DM), and low carbohydrate ($17.96\% \pm 2.39\%$ DM), ash ($2.76\% \pm 0.19\%$ DM) and cellulose ($3.84\% \pm 1.57\%$ DM) contents. This group includes accessions from the two regions (Cascades and Haut Bassins) and distributed in eight departments as follows: 7 accessions from Sindou, 3 from Mangodara, 2 from Banfora, 1 from Ouéléni 2, from Orodara, 2 from Kangala. Only the average protein content was comparable to that of the other groups, *i.e.* $20.44\% \pm 1.78\%$ compared to $20.34\% \pm 1.58\%$ for group II and $20.98\% \pm 1.23\%$ for group III.

Group II consisted of 16 accessions, *i.e.* 30.18% of the cashew accessions studied, from the two regions (Cascades and Haut Bassins), including 5 from the

Table 3. Nutritional performance of cashew nut accession groups.

Variables	Moisture (%)	Ash (%)	Cellulose (%)	Fat (%)	Protein (%)	Carbohydrates (%)	Energy value Kcal/100g
Groups							
G I	4.38 ± 0.33	2.76 ± 0.19	3.84 ± 1.57	54.99 ± 1.51	20.44 ± 1.78	17.96 ± 2.39	648.54 ± 11.83
G II	4.59 ± 0.31	2.91 ± 0.37	7.33 ± 2.44	45.80 ± 2.21	20.34 ± 1.58	23.61 ± 4.16	588.00 ± 13.09
G III	4.77 ± 0.43	2.94 ± 0.21	3.09 ± 1.13	50.99 ± 1.68	20.98 ± 1.23	21.99 ± 2.21	630.86 ± 8.15
P-value*	0.008	ns	<0.0001	<0.0001	ns	<0.0001	<0.0001

*Statistics of the Univariate Test of equality of group means. Ns: Not significant.

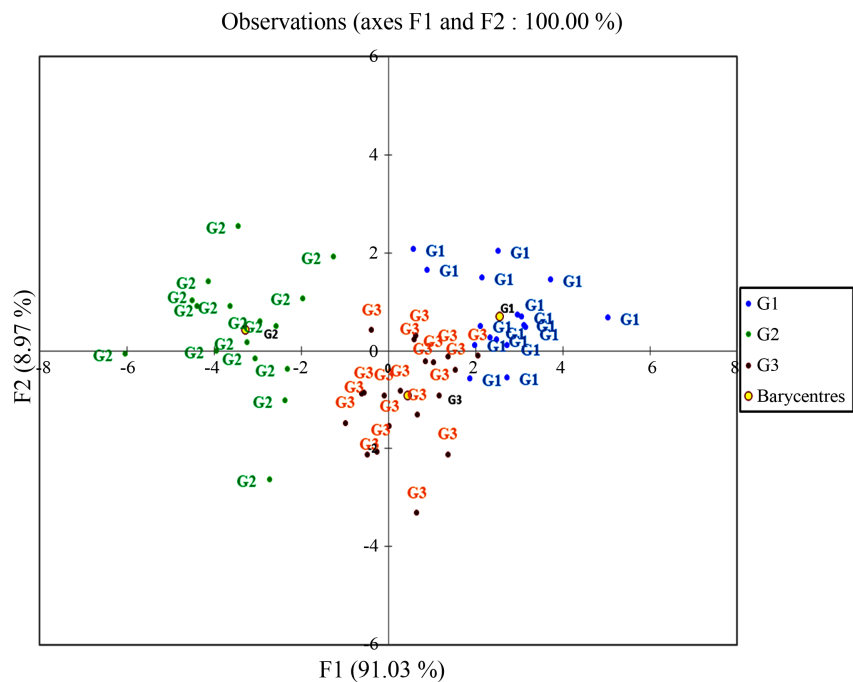


Figure 3. Expression of nutritional diversity of cashew accessions.

department of Sindou, 3 from Soubakagniedougou, 2 from Banfora, 1 from Mangodara, 1 from Loumana, 3 from Orodara and 1 from Kangala. The cashew accessions in this group are opposite to those in group I and were characterised by high carbohydrate (23.61% ± 4.16% DM) and cellulose (7.33% ± 2.44% DM) contents, and lower lipid (45.80% ± 2.21% DM) and energy (588.00 ± 13.09 Kcal/100g) contents. Their protein contents were comparable to that of the other two groups.

Group III is made up of 20 accessions, *i.e.* 37.73%, spread over two regions (Cascades and Haut Bassins), including seven from Sindou, three from Soubakagniedougou, three from Mangodara, one from Dakoro, two from Orodara and four from Kangala. The accessions in this group are characterized by high ash content (2.94% ± 0.21% DM), average lipid content (50.99% ± 1.68% DM), energy content (630.86% ± 8.15% DM), protein content (20.98% ± 1.23% DM)

and carbohydrate content ($21.99\% \pm 2.21\%$ DM), but very low cellulose content ($3.09\% \pm 1.13\%$ DM), which is lower than that of Group I accessions.

4. Discussion

The 53 cashew nuts of accession samples from Burkina were a core collection from a mass selection of cashew trees of good agro-morphological performances. The selection of these accessions was mainly based on agro-morphological criteria such as crude nut yield, average crude nut weight and nut kernel percentage. The improvement process resulted in the selection of 15 cashew accessions as head clones to boost the production of improved seedlings for the industry [22].

Concerning the overall proximate composition, for all the accessions, the average values found in cashew kernels were comparable to the average values reported by [10] for 11 cashew nut samples of different origins, *i.e.* $3.8\% \pm 0.8\%$ for moisture, $48.27\% \pm 1.55\%$ for lipids, $21.3\% \pm 0.8\%$ for proteins, $20.5\% \pm 1.5\%$ for carbohydrates, 609 ± 8.9 kcal/100g for energy value. Also, they are of the same order of magnitude as data found by on Brazilian cashew nuts [29]. In addition, higher lipid contents were reported on nine cashew nut samples from Indonesia *i.e.* $66.21\% \pm 7.87\%$ [30].

Although lipids represent the major constituent of cashew kernels carbohydrates represent the second major constituent of kernels with values close to proteins. Concerning the moisture content, the average values obtained in this study were lower than those reported on cashew nut flours, *i.e.* $5.7\% \pm 0.2\%$ [31]. The average ash values are also comparable to those reported with cashew nuts from Cote d'Ivoire [32]. However, they are in line with standard specifications which recommend cashew nuts with a moisture content below 5% [33]. Interestingly, cashews with low moisture content (<5%) could have the advantage to be stored for longer periods of time without microbial growth or changes in undesirable biochemical compounds [34]. The comparison with the physicochemical and nutritional characteristics reported for Brazilian peanut seeds shows that the latter are richer in protein ($29.59\% \pm 0.05\%$), lower carbohydrate contents (13.06%) and comparable lipid contents ($46.35\% \pm 0.26\%$) [10]. Present results also show that the average cellulose content obtained, $4.61\% \pm 2.52\%$, is higher than those reported elsewhere [10] [29] [31] with values of $1.2\% \pm 0.3\%$, $3.92\% \pm 0.05\%$ and $3.6\% \pm 0.2\%$, respectively. The consumption of cashew kernels with high cellulose content could facilitate digestion and prevent constipation which is the cause of some diseases such as hemorrhoids, colon cancer, appendicitis, etc. [32]. Differences related to the origin of the samples, the processes (storage and manipulation), and the methods used for cellulose analysis may explain these differences observed between studies.

In terms of analysis of variability within the cashew accessions nut samples, univariate analyses, including principal component analysis (PCA), hierarchical ascending classification (HAC) and discriminant factor analysis (DFA) allowed the identification of the main discriminant parameters respectively, which are li-

pids. The 53 cashew accessions were classified into three homogeneous groups consisting of accessions with high nutritional potential, which could be used in varietal selection programs.

Group I is represented by accessions ET01, ET06, ET09, ET11, ET16, ET17, ET18, ET19, ET20, ET25, ET37, ET42, ET47, ET53, ET54, ET62, ET63. They are particularly rich in lipids and energy, low in carbohydrate and cellulose and medium in protein. From a nutritional point of view, this group contains the best accessions that can be valorized by breeding programs and that could find many uses in agri-food and particularly in energetic food formulation programs to fight against undernutrition. Given the high number of accessions in this group, one could think of the presence of duplicates and the need to deepen the knowledge on other physico-chemical and nutritional parameters.

Group II includes accessions ET02, ET07, ET12, ET14, ET15, ET24, ET26, ET28, ET32, ET43, ET46, ET55A, ET55C, ET57, ET67, ET69. From a nutritional point of view, they are less interesting than group I and III accessions, due to their lower lipid and energy contents and high carbohydrate and cellulose contents. These accessions with low nutritional potential could be used as foodstuffs and for the development of dietetic foods.

Group III includes accessions ET03, ET04, ET05, ET08, ET10, ET13, ET21, ET22, ET23, ET27, ET29, ET30, ET31, ET45, ET48, ET49, ET50, ET52, ET55B, ET60, which also have an interesting nutritional potential, although lower than those of group I.

The large variability in nutritional composition observed may be attributable to various environmental factors [35], processes (storage and handling), cultivation and harvesting methods and conditions. Other work on other species has reported that environmental conditions may not be the only cause of variation in the physico-chemical composition of the kernels. Indeed, genetic factors could also influence them [36]. Such hypotheses are confirmed by our results which showed that the variation in the overall composition of the kernels was not a function of the agroecological origin of the accessions, suggesting the influence of these genotypic factors.

5. Conclusion

There is large diversity with respect to proximate compositions and potential nutritional values among cashew accessions available in Burkina Faso. Data analysis allowed to classify accessions into three significantly distinct groups. The grouping of accessions independently of their phytogeographical origin suggests the involvement of genetic factors in the variation of the traits of interest. In view of these results, this study is an important step towards identifying the best cultivar to be used for breeding for commercial valorization.

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Conflicts of Interest

The authors collectively declare that there are no conflicts of interest in this article.

Authors' Contributions

The study protocol was drafted by JNS and LTS-O; the manuscript was written by JNS, LTS-O and MHD. WVT and FB performed the statistical analyses. Scientific supervision of study was provided by LTS-O and MHD.

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