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Effects of Roasting, Germination and Cooking on the Nutritional Value of Peanut Seeds JL-24 (*Arachis hypogaea*)

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Abstract

Peanut (*Arachis hypogaea*) is one of vegetable plant that accumulates nutrient reserves mainly consisting of proteins, carbohydrates, lipids, vitamins and minerals. However, it also contains several antinutritional compounds, such as phytic acid, oxalates and trypsin inhibitors that can reduce the bioavailability of some essential nutrients. The aim of this study was to evaluate the effect of roasting (at 120 °C; 25 min), germination (96 hours) and cooking (100 °C/15 min) on the nutritional value of the variety JL-24 peanut seeds (*Arachis hypogaea)*. To achieve this, peanut seeds of variety JL-24 were purchased in station of the Agricultural Research Institute for Development (IRAD) in Ngaoundere, they were then sorted, separated into batches and subjected to different treatments. The contents of macronutrients (protein, lipids, carbohydrates, fiber, ash), micronutrients (total carotenoids, Fe, Ca, Zn, Na, Mg, P, K) and antinutrients (phytate, oxalate, trypsin inhibitors) were determined by standard methods. From the results of this study, it appears that roasting, germination and cooking led to an increase in the protein, lipid, carbohydrate and mineral contents of peanut seeds. These 03 treatments also led to a reduction in the total fiber contents and especially in antinutritional factors (phytates, trypsin inhibitors and oxalate). Comparatively to other method, the germination of peanut seeds provided better nutritional values as well as better percentages of reduction of antinutritional factors. This treatment would be highly recommended in the formulation of a healthy, digestible and highly accessible complementary food for children under 59 months.

Keywords: Nutritional Value, Peanut Seeds, Technological Processing, Roasting, Germination, Cooking

1. Introduction

Nutritient deficiencies remain a major and widespread public health problem with a ratio of at least 33 % of the population affected by at least one of its forms [1]. Worldwide, 2.4 billion people suffer from nutritient deficiencies [2] while in sub-Saharan Africa, 675 million people are victims of malnutrition due to nutritient deficiencies. In 2023, it was estimated that at least 467,362 people suffer from overall nutritients deficiencies in Cameroon [3]. These nutritients deficiencies are most often caused by nutritional insufficiency in the diet and poor absorption of nutrients [4]. Therefore, micronutrient supplementation, which is the use of micronutrient-rich medicinal products, has been used to address this problem, but factors such as poverty, inadequate prescription duration, insufficient dose, and poor route of administration have not been successful in solving the problem of nutritional deficiencies. Nutrient deficiencies impose enormous economic and social burdens on health; thus, finding accessible nutrient-rich food sources remains an elusive challenge [5]. Animal products are good sources of nutrients, but they are expensive and sometimes of questionable reliability. Thus, plant-based products, such as legumes, have emerged as good alternative sources of nutrients and constitute an important food group in many countries. The nutritional value of vegetables is generally poorly understood, and their consumption is not fully appreciated. Many actions are therefore being carried out to raise awareness among the population about the nutritional value of legumes. It is with this in mind that the Food and

Agriculture Organization of the United Nations (FAO) has proclaimed 2016 the International Year of Pulses under the slogan "Nutritious Seeds for a Sustainable Future" [6]. In fact, this promotion amounts to partially replacing meat with the consumption of pulses, particularly peanuts.
Peanut (*Arachis hypogaea L.*) exists in different varieties distinguished by the shape, color and size of the seeds multiplied constantly like: JL-24, ICGV, 86003 and Metchitcha of which the most widespread variety is JL-24 thanks to its high yield [7]. It belongs to the subfamily Papilionaceae and accumulates in its cotyledons its nutritional reserves mainly consisting of proteins, carbohydrates, lipids, vitamins A, E, D and mineral salts (Na, P, Ca, Mg and Iron) [8]. However, they contain several antinutritional compounds, such as phytic acid, oxalates and trypsin inhibitors which can reduce the bioavailability of some essential nutrients. Phytic acid affects the bioavailability of essential minerals such as calcium, iron, magnesium and zinc [9].
Therefore, to improve the nutritional value for optimal use of vegetables, it is essential to eliminate or reduce the activity of antinutritional factors. In addition, the work conducted by Afwa *et al.* showed that germination of peanut seeds increases the percentage of antioxidant activity [10]. Studies conducted by Olowole *et al.* showed that some treatments such as cooking and germination increase the protein content, antioxidant activity, lower the glycemic index of peanut [11]. However, most of these methods have not been applied locally due to the long implementation time, lack of practical experience and especially the dietary habits of individuals. It is in this perspective that the present study consists of examining the effect of roasting, germination and cooking on the nutritional value of peanut seeds **JL-24** (*Arachis hypogaea*). To do this, we used a number of materials and methods.

Material and methods

Plant material

It is made from the **JL-24 variety** of peanuts (*Arachis hypogaea*) purchased in a market in the city of Douala.

Fig 1: Variety of JL-24 peanuts

Methods

Sampling

The peanut seeds of variety JL-24 were collected at the multipurpose station of the Agricultural Research Institute for Development (IRAD) in Ngaoundere (7° 14' 00' North, 13° 35'00' East)., identified and then transported to the Biochemistry laboratory, at the Food Sciences and Nutrition of the University of Douala.

Processing of samples

After collection, the samples were transported to the Biochemistry, at the unit of Food Sciences and Nutrition Laboratory of the University of Douala where they were sorted, processed and then stored in polystyrene plastic bags in batches until processing. The sample processing activities before analyses of different is summarized in the following diagram:

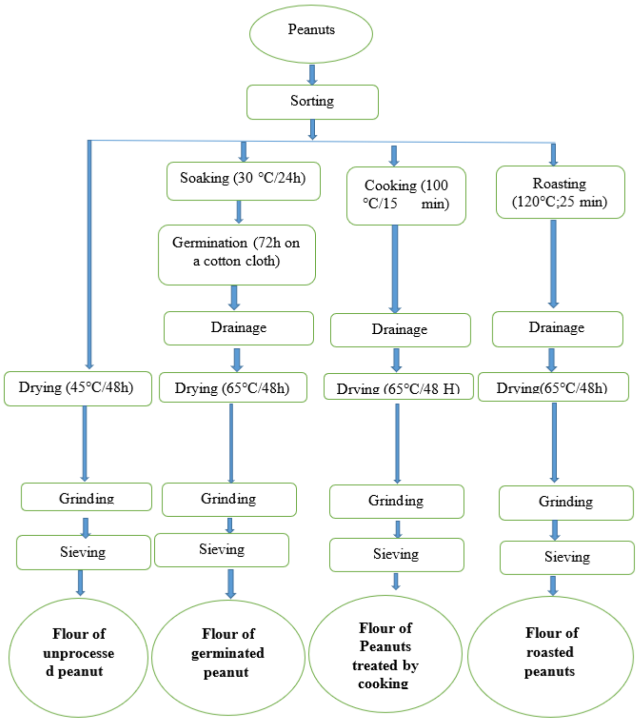

Fig 1: Peanut seeds processing flowchart

Chemical analyses of different sample batches (treated and untreated)

This analysis focused on determining the composition in macronutrients, certain essential micronutrients in our samples, treated or not, for good growth in children under 59 months and certain antinutritional factors.

Macronutrient content

Dry matter and fiber contents were determined by the AOAC method [12] after mass loss of the samples by steaming at 105 °C, total protein contents based on the total nitrogen dosage were determined after mineralization of the samples according to the Kjeldahl method. after determination of the total nitrogen content and multiplication of this content by 6.25 [13]. Total lipid contents were determined by the method described by Bourely [14]; total carbohydrate contents relative to dry matter were determined by the differential method. Total ash contents were determined according to the method described in AFNOR [15] based on completely incinerating a sample until white ash is obtained in a muffle furnace set at 550 °C. The energy value was calculated according to the following formula:

Energy value = % Protein*4 + % Fat*9 + % Carbohydrate*4

Determination of micronutrient contents of sample batches (treated and untreated)

Total carotenoids were measured by the AOAC method [16] whose principle is based on the filtration of the sample with 30 ml of the hexane-acetone mixture 30/70 (v/v). The minerals Ca, Na, Mg and K, P, Fe and Zn were analyzed using an atomic absorption spectrophotometer (Perkin-Elmer 5100 PC) equipped with a hollow cathode lamp (P809) [17].

Determination of anti-nutritional factor contents in sample batches

The determination of phytate contents of peanuts was done by the method described by Olayeye *et al* [18], the oxalate content was determined by the *titration method* and the trypsin inhibitor content of the samples was determined by the method described by *AOAC*, [12].

Determination of molar ratios of the three processed peanut flours

The molar ratios (Phytate/Ca, Phytate/Fe, Phytate/Zn, Oxalate /Ca) were determined by dividing the number of moles of phytate or oxalate by the number of moles of the different minerals.

Statistical analyses

Statistical analyses of the data were performed using IBM/SPSS 20.0 (Statistical Package of Social Science) software for Windows. The analysis of the survey data was done using frequencies and cumulative frequencies. The post hoc comparison test "Tukey" at the 5 % significance level was used to compare the means. The results obtained were presented in the tables as mean ± standard deviation.

Results and discussion

The results obtained in theses research works are summarized in Tables 1 to 4.

Macronutrient contents of flours from treated and untreated peanut samples

Table 1 below shows the water, protein, lipid, carbohydrate, fiber and ash contents as well as the energy contributions of the different peanut flours before and after the different technological treatments undergone.

The protein, fat and carbohydrate contents of sprouted peanut flour **ATG** (28.40±0.07 g/100 g DM; 46.30±0.13 g/100 g DM; 13.50±0.05 g/100 g DM respectivel) were higher (P <0.05) than those of untreated peanut flour **ANT**, roasted peanut flour **ATC** and roasted peanut flour **ATT**. Roasted peanut flour and cooked peanut flour were found to have high water contents (7.24±0.01; 5.40±0.10 g/100 g DM).

Table 1: Macronutrient contents (g/100 g dry matter) of peanut flours before and after the different treatments

	ANT	ATG	ATT	ATC
Water contents	4.70± 0.10 c	3.50± 0.10 d	7.20± 0.01 a	5.40±0.10 b
Protein contents	24.30± 0.10 c	28.40± 0.10 a	26.70± 0.06 b	28.30±0.20 a
Lipid content	45.70± 0.20 a	46.30± 0.10 a	42.60± 0.40 c	44.90±1.50 b
Carbohydrate contents	13.50± 0.10 a	13.60±0.04 a	10.40± 0.04 b	5.30±0.08 c
Fiber contents	8.70± 0.10 a	5.50± 0.09 c	7.10± 0.07 b	5.30±0.08 c
Ash contents	2.58± 0.10 c	2.48± 0.03 c	5.10± 0.02 a	4.50±0.08 b
Energy Kcal/100 g. DM	**522.00**	**584.70**	**531.80**	**538.50**

Values are the means ± standard deviation of triplicate determinations, means within the same row with different superscripts are significantly different at p < 0.05. ANT: Untreated peanut flour; ATT: Roasting-treated peanut flour; ATG: Sprouting-treated peanut flour; ATC: Baking-treated peanut flour

The results showed that roasting-treated peanut flour (**ATT**) (7.20±0.01g/100 g DM) had the highest water content. This result corroborates with the studies of Maurice O. [19]. Sprouted peanut flour (**ATG**) had the lowest water content (3.52±0.04 g/100 g). Both cooking-treated peanut flour (**ATC)** (5.40±0.01g/100g) and sprouted peanut flour (**ATG)** (3.50±0.01g/100g) have low water content which is within the recommended range of 0-13.5 % [20]. This implies that these flours had lower water activity, which can inhibit the growth of microorganisms and thus prolong their nutritional quality and storage capacity. The moisture content of the four peanut flours in this study was comparatively higher than that reported by Olowale *et al* [21] for raw, cooked, sprouted and fermented peanuts ranging from (1.30 to 2.87 g/100 g DM).

Biochemical analyses showed that the flour produced from sprouted seeds (**ATG)** had a protein content of 28.40±0.01g/100 g DM which had increased significantly at the 5 % threshold. This same observation was made by Ingale and Shrivastava [22]. These authors revealed that the protein level had increased by 3 to 4 % in sprouted cereal and legume seeds after 72 hours of germination. This increase in the protein level would be due to the decrease in the water content of this flour, thus making the proteins more concentrated [23]. The protein levels found in sprouted peanut flour were higher than those found by Gnanwa *et al.,* [24] in Ivory Coast. Proteins play an essential role in the structuring and renewal of muscle tissues, organs such as bones, skin, hair, nails as well as hormones. So sprouted peanut flour is then the best source of protein for food. Proteins are the main building blocks of the body. Therefore, a constant and good quality supply is necessary to maintain growth and ensure other physiological functions [25].

The carbohydrate contents of our study showed that the processed peanut flours could be used for the formulation of complementary foods. The carbohydrate contents (10.40±0.04g and 13.60±0.04 g/100 g DM) were low compared to those reported by Oluwajuyitan *et al.,* [26] for roasted and sprouted peanut flours respectively (34.97 % and 24.4 5%). These differences could be explained by production conditions, varieties and soil nature. All processing methods increased carbohydrate contents except for the baking-treated flour (**ATC)** (5.30±0.08 g/100 g DM). This implies that peanut processing methods increase the bioavailability of carbohydrate molecules.

Regarding lipid contents, sprouted peanut flour (**ATG)** (46.30±0.1 g/100 g) had the highest value, while roasted peanut flour (**ATT)** (42.60±0.40 g/100 g) had the lowest value and the result showed that the lipid content in processed flours was significantly higher than that of raw flour. This can be explained by the fact that lipids are degraded into free fatty acid. On the other hand, the lipid contents of peanut samples in this study were consistent with 49.0% of raw peanut reported by Audu and Aremu [27].

The ash contents of the different flours ranset from 2.58 to 5.10 g/100 g DM. The values were in the range of 2.65 to 5.51 g/100 g DM of ash content for the different processed peanut flours reported by David *et al*., [28]. However, crude fiber contents decreased during cooking (**ATC**) (5.30±0.08 g/100 g DM) and germination (**ATG**) of peanuts (5.50±0.09 g/100 g DM) except for roasted peanut flour **ATT** (7.10±0.07 g/100 g DM). The drastic decrease in fiber contents of sprouted flours compared to other processing methods could be explained by the degradation of cellulose under the combined action of several enzymes (exo-1,4-â-D-glucanase, endo-1,4-â-D-glucanase and â-glucosidases called cellulase complex, enzymes initiated by the germination of legumes [3]. The work carried out by Gnanwa *et al.,* [24] found similar results on the decrease in fiber content of sprouted peanuts in Ivory Coast (5.76 ± 0.18 to 3.81 ± 0.23 mg/100 g DM).

The low ash content of flours could be due to the solubilization of salts and minerals in the cooking water [29].

All treatments resulted in an increase in energy intake. Sprouted peanut flour had the highest energy value (584.70 kcal), followed by cooked peanut flour (538.50 kcal) and then roasted peanut flour (531.80 kcal).

Micronutrient contents of flours from treated and untreated samples

Table 2 below shows the total carotenoid, iron, calcium, phosphorus, magnesium, zinc, sodium and potassium contents of the different peanut flours before and after the different technological treatments undergone.

The different technological treatments of peanuts (peanut flours treated by roasting **(ATT)**, by germination **(ATG)**, by cooking **(ATC)** significantly increased the mineral contents of the treated flours compared to untreated peanut kernel flours. Among the treatment methods, it appears that germination had better Ca, Mg, Zn, Na contents than roasting and cooking peanuts. Cooking had better iron contents than other technological treatments.

Table 2: Micronutrient contents (mg/100 g DM) of flour samples before and after treatment

	ANT	ATT	ATG	ATC
Iron contents	5.70± 0.20 ^{b}	4.60± 0.10 ^{c}	5.60± 0.10 ^{b}	6.30±0.20 ^{a}
Calcium	106.50±0.85 ^{d}	140.70±0.70 ^{b}	140.90±0.60 ^{a}	117.90±0.50 ^{c}
Phosphorus	375.80±0.30 ^{d}	398.10±0.30 ^{a}	380.07±0.70 ^{c}	387.30±0.30 ^{b}
Magnesium	170.20±0.20 ^{c}	168.20±0.30 ^{d}	176.10±0.50 ^{a}	173.40±0.40 ^{b}
Zinc	2.40±0.09 ^{c}	2.20±0.05 ^{c}	4.50±0.10 ^{a}	3.20±0.10 ^{b}
Sodium	5.20±0.10 ^{c}	4.40±0.10 ^{d}	6.50±0.10 ^{a}	5.70±0.10 ^{b}
Potassium	278.40±0.50 ^{d}	289.90±0.10 ^{c}	308.07±0.70 ^{a}	298.00±0.50 ^{b}

Values are the means ± standard deviation of triplicate determinations. Means within the same row with different superscripts are significantly different at p < 0.05. ANT: Untreated peanut flour; ATT: Roasted peanut flour; ATG: Sprouted peanut flour; ATC: Baked peanut flour

From the results of the analysis of the mineral composition of different untreated and treated peanut flours (ANT, ATT, ATG, ATC), it appears that peanut is quite rich in minerals. The different technological treatments of peanut seeds namely roasting, germination and cooking have all led to increases in mineral contents and these increases are more significant with regard to the treatment of peanuts by germination (ATG). This increase would be attributed to the activity of phytases activated during germination. These enzymes allow to reduce phytic acids that bind to minerals, subsequently leading to greater availability of minerals [30]. In addition, it should be remembered that the significant increase in the bio-accessibility of minerals is linked to the decrease in the content of antinutritional compounds [31]. Therefore, the consumption of sprouted peanut seeds would then be recommended for the prevention of certain diseases by strengthening the immune system, especially thanks to minerals such as magnesium and zinc [32].

Antinutritional factor contents of peanut flours

Table 3 below shows the phytate, trypsin inhibitor and oxalate contents of treated and untreated peanut flours.

From this table, it appears that all three treatments resulted in reductions in the various antinutrient factors of the flours analyzed. This was at least 30 % in phytates (peanut flour treated by ATC cooking) and at most 60 % in oxalate (peanut flour treated by ATC cooking).

Peanut flour treated by germination showed overall better reduction rates in phytates and trypsin inhibitors than flours treated by roasting (ATT) and cooking (ATC).

Table 3: Antinutritional factor contents (mg/100 g DM) in peanut flours after the different treatments and their respective reduction percentages

	ANT	CTT	% R (ATT)	ATG	% R (ATG)	ATC	% R (ATC)
Phytates	0.20± 0.04^{a}	0.10± 0.02^{a}	50.00	0.10±0.01^{a}	50.00	0.14±0.02^{a}	30.00
Trypsin inhibitors	2.31±0.05^{a}	1.33± 0.03^{b}	42.42	1.05± 0.00^{c}	54.54	1.12±0.02^{c}	51.51
Oxalates	7.70± 0.30^{a}	4.50± 0.1^{b}	41.55	3.90±0.06^{c}	49.35	3.06±0.04^{d}	60.25

Values are the means ± standard deviation of triplicate determinations. Means within the same row with different superscripts are significantly different at p < 0.05. ANT: Untreated peanut flour; ATT: Roasted peanut flour; ATG: Sprouted peanut flour; ATC: Baking peanut flour; % R: Percent of reduction

From this table 3, we note that the different treatments all contributed to the reduction of phytate, trypsin inhibitor and oxalate contents. These results corroborate those obtained in Nigeria by Okaraonye *et al.,* [33] who noted a decrease in the contents of phytates, trypsin inhibitors and oxalates in the flour of sprouted and cooked peanut grains compared to the flour of raw grains. These decreases are due successively to the effects of heat and those of microorganisms which modified the chemical structure of these anti-nutrients, making them less active and unable to interfere with the absorption of nutrients. Indeed, anti-nutrients, mainly phytates and oxalates, can be digested under the effect of heat and also that of microorganisms. This action leads to the release of divalent cations (Fe, Ca, etc.) which were trapped, and consequently improves their bio-accessibility [34, 35]. Since germination involves both heat and enzymes, we understand why the results of the analyses showed better percentages of reduction under treatment of sprouted peanut flours. These reductions in antinutrient factors would also explain the low levels below the threshold value of phytate/iron molar ratios, which increases the bio-accessibility of minerals.

Molar ratios of processed peanut flours

The following Table 4 shows the calculated phytate/mineral molar ratios of the three processed peanut flours; the phytate/iron molar ratio is one of the *in vitro* bioavailability assessment methods that can be used to estimate iron bioavailability. Studies conducted by Gibson *et al.* [36] also proposed the use of phytate/iron molar ratios to assess non-heme iron absorption. Phytates begin to lose their inhibitory effect on iron absorption when phytate/iron molar ratios are lower than 1.0 (in the presence of activators in the food), or even ratios as low as 0.2 (in the absence of activator), for cereal or legume-based dishes. According to Gemede *et al.,* [37] Phytate/iron molar ratios greater than 0.15 are considered indicative of low iron bioavailability (Table 4). The molar/zinc ratio is that used to assess the *in vitro* bioavailability of zinc in the body; this ratio should be less than 10 (<10). Zinc is an essential constituent of a large number of enzymes and plays a central role in cell growth and differentiation in tissues that exhibit a high rate of differentiation and renewal, such as those of the immune system and the digestive tract. Zinc bioavailability depends on the composition of the diet, particularly the proportion of foods rich in phytates (certain cereals and vegetables), the addition of animal proteins to the diet [38,39].

From this table, it emerges that the three peanut treatments, namely roasting, germination and cooking, have Phytate/Iron molar ratios lower than normal (0.15), which implies that the three flours, namely ATT, ATG, ATC, will have high bioavailability of iron and zinc essential for the well-being of children under 59 months.

Table 4: Summary of molar ratios of the three processed peanut flours

	ATT	ATG	ATC	STANDARD
Phytate/Fe	0.021	0.017	0.022	< 0.15
Phytate/Ca	0.0007	0.0007	0.001	<0.24
Phytate/Zn	0.04	0.02	0.04	<10
Oxalate/Ca	0.03	0.02	0.02	<1

ATT: Peanut flour treated by roasting; ATG: Peanut flour treated by germination; ATC: Peanut flour treated by cooking

The millimolar ratios of phytates, oxalates, and minerals (i.e., bioavailability indices of Ca, Fe, Zn) of the four peanut flours were below the recommended critical levels of <0.24 for Phy/Ca, <0.15 for Phy/Fe, <10 for Phy/Zn, and <1.0 for Ox /Ca, indicating good bioavailability of these nutrients [40]. This shows that the concentrations of phytates and oxalates were low to interfere with the absorption and bioavailability of these important minerals (Ca, Fe, Zn), thus preventing their deficiencies. Therefore, all treatments applied to peanut seeds improved their bioavailability of minerals.

Conclusion

This study aimed to evaluate the effects of roasting, germination and cooking on the nutrient and antinutrient contents of JL-24 peanut seeds. (*Arachis hypogaea*). The results showed that roasting, germination and cooking led to an increase in the protein, lipid, carbohydrate and mineral contents of peanut seeds. These 03 treatments nevertheless led to a reduction in the total fiber contents on the one hand and in antinutritional factors (phytates, trypsin inhibitors and oxalate) on the other hand. Comparatively, the germination of peanut seeds provided better nutritional values as well as better percentages in terms of reduction of antinutritional factors. This treatment (germination) would be highly recommended in the formulation of a healthy, digestible and highly accessible complementary food.

Originality of work

The authors declare that this work is original and has not been submitted anywhere.

Additional information

No additional information is available for this article.

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Ethical approval

This article does not contain any studies performed by any of the authors on human or animal subjects.

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