Kabré et al. Journal of Ethnic Foods (2025) 12:9
https://doi.org/10.1186/s42779-025-00268-4

Journal of Ethnic Foods

ORIGINAL ARTICLE

Open Access

Impact of traditional culinary processes on the nutritional quality of beng tigré, a mung bean variety grown in Burkina Faso

Jeanne d'Arc Wendmintiri Kabré[1,2], Fatoumata Hama-Ba[2], Mamadou Sanoué[2] and Aly Savadogo[1*]

Abstract

Resilient to the effects of climate change, Mung bean is a seed legume rich in nutrients and bioactive compounds. The objective of the study was to determine the impact of cooking processes on its nutritional quality. Mung bean seeds of the Beng-tigré variety are obtained from Belwet, the national sponsor. Plain Mung bean seeds (MBN) are germinated for 24 and 48 h; roasted for 15 and 30 min; soaked for 6 and 12 h; dehulled after 6 and 12 h soaking and boiled for 30 and 60 min. The methodology consisted of assessing the macronutrients, minerals and biomolecules of MBN; and then characterizing the flours from the different processes. The results show a significant difference ($p < 0.05$) in nutrient and biomolecule contents between MBN and seeds that have undergone the processes. Protein in MBN (27.02%) increased with germination, cooking and roasting. Phytates in MBN (5.36 mg/g) decreased significantly after 48 h of germination (1.16 mg/g). Iron and zinc decrease with the processes and still have a better bioavailability in the processed Mung bean than in the plain seeds. Polyphenols in MBN (5.2 mg/100g) increase after 12 h of soaking (12.56 mg/100 g) and 48 h of germination (21.5 mg/100 g). Thermal processes induce better water absorption and non-thermal processes better oil absorption and swelling capacities. The results show an influence of the cooking processes on the indices of the different flours. Germination and soaking improve the nutritional value of Mung bean and reduce anti-nutritional substances, making it healthier for consumption.

Keywords Impact, Culinary process, Mung bean, Nutrients

Introduction

The plants of greatest dietary interest to address nutritional and therapeutic deficits worldwide and particularly in Africa belong to the order of legumes [1]. Legumes are commonly used in the formulation of functional foods with beneficial effects on consumer health [2]. They can be consumed cooked, alone or in combination with other grains, sprouted or fermented [3]. Characterized by both high energy and nutrient densities, Mung bean is a legume of Asian origin, with production in India in 2016 estimated at 2.99 million hectares [4]. Several authors have reported that agronomic and soil factors, as well as weather conditions, impact the amount of minerals in the soil which in turn influence their concentrations in Mung bean seeds [5, 6]. Due to its protein and micronutrient composition as well as its sought-after organoleptic quality, Mung bean is used in infant porridge formulations for the management and prevention of malnutrition [7, 8]. Mung bean is recently introduced and valued in Burkina Faso for its resilience to the effects of climate change, its high nutritional value and especially its physiological

*Correspondence:
Aly Savadogo
alysavadogo@gmail.com
[1] Laboratoire de Biochimie Et Immunologie Appliquées, Département de Biochimie Et Microbiologie, Université Joseph KI-ZERBO, Ouagadougou, Burkina Faso
[2] Département Technologie Alimentaire, Institut de Recherche en Sciences Appliquées Et Technologies, Centre National de La Recherche Scientifique Et Technologique, Ouagadougou, Burkina Faso

effects in preventing degenerative diseases such as diabetes, hypertension and cancer [9, 10]. It contributes significantly to food and nutritional security, and to increasing farmers' income in Burkina Faso [11]. Households in Burkina Faso use a variety of traditional thermal and non-thermal cooking methods to consume mung bean [12]. In legumes in particular, to reduce anti-nutrients and increase mineral bioavailability and digestibility, several thermal or non-thermal processing steps are often necessary. Studies have shown that certain culinary transformations impact the nutritional value and functional properties of foods [4]. The objective of this study is to assess the nutritional composition of Mung bean grown in Burkina Faso and to analyze the nutritional impact of culinary processes such as cooking, roasting, sprouting, soaking and shelling in order to know how to preserve or even improve the nutritional value and functional properties of this legume for the benefit of the population.

Materials and methods

Materials

The plant material used consisted of mung bean (*Vigna radiata*) seeds collected from The study involved the only Mung bean variety in Burkina Faso registered in the national catalogue of plant species and varieties at the Institut de l'Environnement et de Recherches Agricoles (INERA) in 2019 under the name Beng-tigré (SCHV 544).

Sample preparation

Samples were prepared based on traditional culinary processes commonly used in Burkina Faso.

The plain seeds of the Beng-tigré variety of Mung bean (MBN) have undergone several thermal and non-thermal processes at different times.

The MBN seeds underwent two thermal cooking processes:

- Boiling in 30 and 60 min after soaking for 12 h in distilled water. This process resulted in samples MBB30 and MBB60 for Mung bean boiled for 30 min and Mung bean boiled for 60 min respectively;
- Roasting for 15 and 30 min yielded samples MBT15 and MBT30 respectively.

Another batch of MBN seeds was subjected to three non-thermal cooking processes:

- A soak in distilled water for 3 h, 6 h and 12 h yields the samples MBTr3, MBTr6 and MBTr12 respectively;
- Dehulling after soaking in distilled water for 6 h and 12 h giving samples MBD6 and MBD12 respectively;
- Germination in 24 and 48 h after hydrating the seeds for 12 h. This process resulted in MBG24 and MBG48 for 24-h germinated Mung bean and 48-h germinated Mung bean respectively.

Methods

Biochemical analysis

The moisture content of the samples was determined in accordance with the French standard [13], which consisted of a differential weighing of a 5 g sample before and after it had been subjected to the study at 130 degrees.

The lipid content was determined according to the [14] standard using the Soxhlet extraction method.

The protein content was determined according to the Kjeldahl method of the [15] standard. The conversion factor considered was 6.25.

The carbohydrate content was obtained according to the formula of [16].

Carbohydrate content (%) = 100—[protein (%) + fat (%) + ash (%) + water (%)].

The energy value was calculated using the coefficients of [17] according to the following formula:

Energy (Kcal/100g) = % carbohydrate × 4 (Kcal) + % protein × 4 (Kcal) + % fat × 9 (Kcal).

The mineral contents were determined by flame atomic absorption spectrometry using [18].

The determination of total polyphenols was carried out by an adaptation of the protocol of [19] using the commercial Folin–Ciocalteu reagent.

The determination of phytates was carried out following the protocol developed by [20].

The culinary quality assessment of water absorption capacity and water solubility index were determined according to the method of [21]. The swelling and oil absorption capacity of the different samples were evaluated according to the protocol of [22].

Statistical analysis

The results are expressed as the mean values of three separate determinations, except for the contents of minerals, total phenols and phytates, which were determined in duplicate. The Excel spreadsheet (2010) was used for the calculation of means and standard deviations. The data were statistically analyzed using ANOVA with XLSTAT software. Differences were considered significant for $p < 0.05$.

Results and discussion

Effect of thermal and non-thermal processes on the macronutrient composition of mung bean

Table 1 shows the macronutrient content of Mung bean that underwent thermal and non-thermal processes. The

Table 1 Effect of thermal and non-thermal processes on the macronutrient content of mung bean

	Protein in g/100g		Fat in g/100g		Carbohydrate in g/100g		Energy in kcal/100g
MBN	27.02	±0.26c	1.33	±0.02a	60.17	±0.21h	360.81 f
MBG24	27.73	±0.11b	0.74	±0.02ef	62.57	±0.07f	367.94 e
MBG48	28.36	±0.07a	0.72	00f	63.69	±0.41e	374.80 c
MBB30	27.90	±0.02b	1.07	00b	61.45	±0.06g	367.12 e
MBB60	25.20	±0.05f	0.96	00bc	68.34	±0.05a	382.92 a
MBD6	25.37	±0.09f	0.72	±0.01f	66.54	±0.08c	374.25 c
MBD12	25.95	±0.01e	0.75	±0.02ef	67.32	±0.25b	379.91 b
MBTr3	24.85	±0.16g	0.87	±0.05cd	64.88	±0.65d	366.84 e
MBTr6	25.45	±0.22f	0.60	±0.09g	66.68	±0.1bc	373.98 c
MBTr12	26.09	±0.15de	0.84	±0.03de	67.00	±0.07bc	380.00 b
MBT15	27.29	±0.01c	1.02	±0.01b	60.35	±0.06h	359.83 f
MBT30	26.35	±0.38d	0.73	00f	64.80	±0.11d	371.22 d

Values are expressed as mean ± standard deviation; within a column, if the letters are different, this indicates a significant difference ($p < 0.05$)

results show an impact on macronutrients with a significant difference depending on the process.

The Beng-tigré variety of Mung bean grown in Burkina is an excellent source of protein (27.96%). Our results are close to those found by [23] which were 27.5%. However, they are far from those of [24] and [4], which were respectively 23.86% and 30.64%. Mung bean counts several varieties and this disparity in protein contents could be due to these multiple varieties but also to storage conditions that influence the nutritional value of legumes according to [25, 26].

Domestic processing of MBN has a significant impact on macronutrients. The protein contents of MBG24 and MBG48 are 27.73% and 28.36% respectively. There is a significant difference in protein between MBG and MBN on the one hand and between MBG24 and MBG48 on the other. This increase in protein content was reported by [23] who observed that after germination of Mung bean the protein content increased from 27.5 to 30.0%. The increase in protein content with germination time is thought to be due to the increase in non-protein nitrogen content during the process releasing bounded nitrogen compounds such as tannin-protein bonds. Also, the increase in proteases during germination leads to a degradation of large molecule proteins into small molecule proteins according to the study of [27]. For cooking and roasting, the results show that the protein content decreases with the time applied. MBB30 and MNB60 have 27.90% and 25.37% respectively. For roasting, MBT15 and MBT30 have 27.29% and 26.35% respectively. This decrease in protein could be due to the presence of heat-labile proteins in the Mung bean which are destroyed by temperature.

The lipid content (1.33%) of plain Mung bean remains low compared to other legumes of the same rank such as soybean which is 18.73% [28]. Studies have reported similar values for plain Mung bean of 1.85% and 1.15% according to [23, 24] respectively. Higher values were found in [4] which were 2.58%. These differences could be related to soil types, genetic and environmental factors [29]. The different domestic processes resulted in a decrease in lipids without a significant difference with MBN except for germination. This significant decrease in lipids during germination is thought to be due to the use of energy contained in the seed to initiate germination.

The carbohydrates of MBN (60.17%) increase significantly with the different processes applied, except for MBT15 (60.35%). These carbohydrates increase significantly with sprouting, soaking, hulling and roasting due to heat-induced denaturation on the one hand, and leaching which will have reduced the other components leading to the increase in hydrates on the other. The processes with the highest carbohydrate content are MBB60, MBD12, and MBTr12, which are 68.34%, 67.32% and 67.00% respectively.

The energy value of MBN (360.81 kcal/100 g) increases with the different processes except for MBT15 which is 359.83 kcal/100 g. MBG48 (374.80 kcal/100 g) is energetically richer than MBG24 (367.94 kcal/100 g) in spite of the decrease in lipid content during germination. The increase in energy value with germination time is related to the increase in protein content during the process. Significant differences were observed in the different times of the soaked Mung bean; this could be explained by the increase of the carbohydrate content with soaking time. The energy values of MBB30 (367.12%) and MBB60 (382.92%) increased significantly with cooking time. [30] had also reported the increase in energy value of Mung bean with boiling time.

Influence of thermal and non-thermal processing on the micronutrient composition of mung bean

Impact of culinary processes on minerals

Figure 1 shows the different Zinc and Iron contents of natural and processed Mung bean.

Our results show a significant difference between plain Mung bean (MBN) and sprouted, soaked, dehulled, roasted and boiled Mung bean for both iron and zinc. The Zinc content of MBN (3.32 mg/100 g) shows a significant difference with the other samples except for MBB30 (3.33 mg/100 g). It increases significantly with germination, i.e. 3.38 mg/100 g for MBG24 and 3.7 mg/100 g for MBG48. The zinc content also increases with hulling and soaking. On the other hand, it decreases significantly with roasting, i.e. 3.16 mg/100 g. The iron content of MBN (7.44 mg/100 g) decreases significantly with the applied cooking processes. This decrease is even more pronounced with cooking, soaking and hulling, which are 6.64 mg/100 g, 7.03 mg/100 g and 7.03 mg/100 g respectively for MBB30, MBTr12 and MBD12. Our results are in agreement with those of [23] who reported a decrease in minerals with the applied technological processes. This significant decrease of iron would be due to a diffusion in the soaking and/or cooking water.

Impact of processes on biomolecules

Figure 2 shows the phytates and polyphenol contents of natural and thermally and non-thermally processed Mung bean.

The analytical results show a significant difference between the phytates of MBN (5.35 mg/g) and those of Mung bean subjected to different processes. Germination MBG24 (1.73 mg/g) and MBG48 (1.16 mg/g) significantly reduced phytates. These results are in agreement with those reported by [31]. The phytate contents of MBTr3 (3.72 mg/g), and MBT15 (3.72 mg/g) on the one hand and MBD6 (2.47 mg/g) and MBD12 (2.47 mg/g) on the other hand did not differ significantly, and time remains insufficient for the reduction of these phytates. Sprouting, soaking (MBTr12), dehulling (MBD12), and roasting (MBT30) are processes that can significantly reduce phytates, which are anti-nutritional substances in Mung bean, but the duration of the process is crucial. Sprouting, cooking and roasting after 30 min are the best processes to reduce phytate content in Mung bean according to our results which are consistent with those reported by [23, 31] for sprouted or cooked chickpeas and Mung bean.

The polyphenols contained in natural Mung bean MBN (5.2 mg/100g) are significantly degraded with shelling and roasting according to our results. These low levels of polyphenols in MBD6 and MBD12 which are respectively 2.61mg/100g and 2.41mg/100g suggest that the polyphenols are located in the germ or wall of the legumes and are eliminated during the hulling process.

The polyphenol contents of MBG24 and MBG48, which are respectively 17.84 mg/100 g and 21.5 mg/100 g, show a very significant increase with germination and

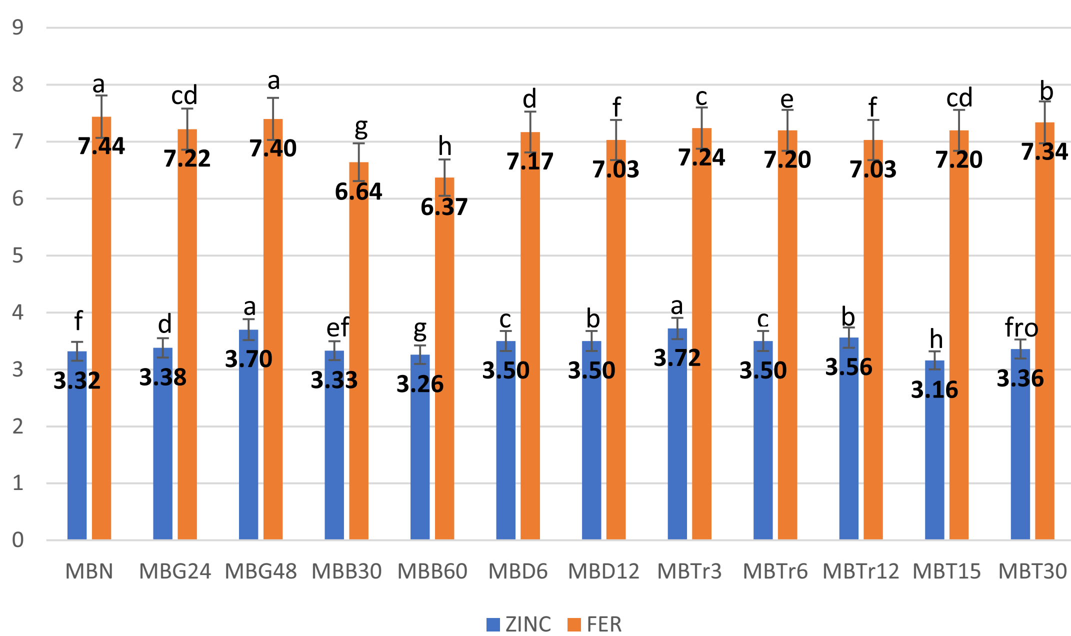

Fig. 1 Effect of thermal and non-thermal processes on the mineral content of Mung bean seeds. The means of Zinc and Iron with different letters at the end of the diagram are significantly different ($p < 0.05$)

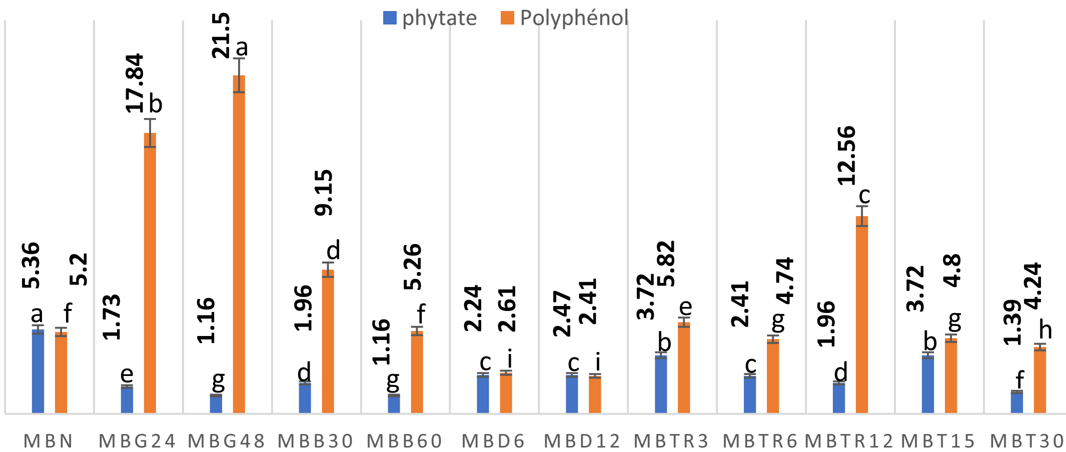

Fig. 2 Effect of thermal and non-thermal processes on the biomolecule content of Mung bean seeds. The means of phytates and polyphenols with different letters at the end of the diagram are significantly different ($p < 0.05$)

germination time. This increase in polyphenols with sprouting in legumes has been reported by [32, 33]. Sprouting in addition to transforming Mung bean into a healthy and digestible food increases the content of polyphenols which are important bioactive molecules with many benefits for the human body according to [32, 34].

Bioavailability of minerals in mung bean

The proportion of the ingested nutrient used by the body's vital biological functions indicates the bioavailability of the food. The technological processes and treatments applied to Mung bean positively influenced the bioavailability of Iron and Zinc. The phytate/mineral ratio shown in Table 2 was used to estimate the proportion of bioavailable Iron or Zinc in plain Mung bean and in Mung bean that had undergone the different culinary processes.

The iron contained in our different flours has a good bioavailability except for MBN, MBTr3 and MBT15 according to the work of [35]. Their work reveals that in humans the phytate/iron molar ratio must be less than 1 or preferably less than 0.4 for good iron absorption in legume or cereal dishes without the addition of activator. Zinc is also very bioavailable in natural Mung bean as well as in those that have undergone various thermal and non-thermal processes according to the work of [36]. This work on rats showed a decrease in zinc absorption for phytate/zinc ratios greater than 15. The different thermal and non-thermal processing of Mung bean improves the iron and zinc bioavailability of Mung bean.

Effect of thermal and non-thermal processes on the different indices of flours from Mung bean processing

The water and oil absorption capacities and swelling of flours play an important role in the food preparation process by influencing a number of functional and sensory properties. Table 3 gives a summary of the characteristics of Mung bean flours according to the cooking processes.

The results show that there is a significant difference between MBN flour and the other flours from the different samples for both water absorption capacity and flour swelling. However, there was no significant difference in water absorption capacity between MBTr3 (46.01%), MBTr6 (45.50%), MBTr12 (45.92%) and MBG24 (45.59%) flours. This water absorption and swelling capacity is believed to be related to the hydrophilic character and the starch granules [37]. Water absorption and swelling result in thickening and increasing the viscosity of the food, thus improving its handling qualities. MBD12 (42.79%) has a low water absorption capacity and will be less workable than MBT30 (53.69%) which has a higher water absorption capacity. [38] correlated the swelling power of the flours with the viscosity of the porridges. For the oil absorption capacity, we note a significant

Table 2 Theoretical bioavailability of Zinc and Iron in natural and processed Mung bean

	MBN	MBG24	MBG48	MBB30	MBB60	MBD6	MBD12	MBTr3	MBTr6	MBTr12	MBT15	MBT30
Phytate/Zinc	1.61	0.51	0.31	0.58	0.35	0.7	0.7	1	0.68	0.55	1.17	0.41
Phytate/Iron	0.72	0.21	0.15	0.29	0.18	0.34	0.35	0.51	0.33	0.27	0.51	0.18

Table 3 Characteristics of Mung bean flours according to culinary processes

	% Absorption capacity		% Oil index		% Swelling	
MBN	46.80	± 0.04e	37.58	± 0.02d	235.00	± 0.04a
MBG24	44.44	± 0.16 g	40.99	± 0.06a	225.00	± 0.02 cd
MBG48	45.59	± 0.03f	35.70	± 0.45f	227.50	± 0.25bc
MBB30	59.89	± 0.57b	36.19	± 0.12ef	225.00	± 0.03 cd
MBB60	64.30	± 0.08a	38.33	± 0.18c	222.50	± 0.10d
MBD6	43.04	± 0.27 h	39.98	± 0.31b	222.50	± 0.39d
MBD12	42.79	± 0.38 h	34.66	± 0.67 g	227,50	± 0.08bc
MBTr3	46.01	± 0.63f	38.39	± 0.22c	225.00	± 0.13 cd
MBTr6	45.50	± 0.01f	37.86	± 0.21 cd	227.50	± 0.44bc
MBTr12	45.92	± 0,38f	37.60	± 0.05d	230.00	± 0.25b
MBT15	47.75	± 0.47d	36.55	± 0.37e	205.00	± 0.14e
MBT30	53.69	± 0.28c	36.01	± 0.36f	222.50	± 0.01d

Values are expressed as mean ± standard deviation; within a column, if the letters are different, this indicates a significant difference ($p < 0.05$)

difference between MBN (37.58%) and MBG24 (40.99%) which records the best absorption capacity. The ability of a food component to trap oil is an important characteristic in fatty food formulations as it would act as a flavor retention device and mouthfeel enhancer according to [39, 40]. The oil absorption capacity of legume flours is negatively correlated with the water absorption capacity. MBT15 (36.55%) and MBT30 (36.01%) which have good water absorption capacity would absorb less oil than MBG24 (40.99%) and MBD6 (39.98%). Processed and unprocessed Mung bean flour has a low oil absorption capacity compared to cowpea (88.3 g/100 g) and horse gram (82.4 g/100 g) according to the findings of [40].

Conclusion

The Beng-tigre variety of Mung bean grown in Burkina Faso is a good source of protein and minerals. The results of this study revealed that thermal processes lead to a decrease in protein and non-thermal processes to an increase; germination being the best of the non-thermal processes contributing to a significant increase in protein content. On the other hand, this sprouting lowers the lipid content and contributes to the reduction of fat in Mung bean. The different cooking processes allow the reduction of phytates in the different samples and improve the bioavailability of minerals. The sprouting and soaking processes contribute to a significant reduction of these anti-nutritional substances contained in the Mung bean. The various cooking processes, whether thermal or not, contribute to a significant increase in the polyphenol content, with the exception of the dehulling process. They also improve the characteristics of the flours from the different samples. Germination after 24 h significantly improves the oil absorption capacity, while cooking increases the water absorption capacity of the flours. The cooking processes affect the chemical composition, anti-nutritional quality and characteristics of the flours from the different samples. Germination and soaking remain the best processes to obtain a healthy food maximizing the crude protein content, minimizing the fat content and reducing the content of anti-nutritional substances.

Acknowledgements
We would like to thank the Department of Food Technology / Institute of Research in Applied Sciences and Technologies (IRSAT) / National Centre for Scientific and Technical Research of Burkina Faso for their technical support.

Author contributions
The first author conceived the study and contributed to data collection, analysis and interpretation, as well as preparation of the manuscript. The second and third authors contributed to the analysis and interpretation of the data, as well as to the preparation of the manuscript. The last author acted as supervisor. All authors read and approved the final manuscript.

Funding
F.H.-B. was a beneficiary of a grant from the McKNIGHT project.

Availability of data and materials
All data and materials are presented in this manuscript.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

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

Received: 12 June 2023 Accepted: 4 February 2025
Published online: 03 March 2025

References

1. Duke, J. A., Okigbo, B. N. and Reed. (1977) Sphenosty/is stenocarpa. Tropical grain legume. Bulletin n• IO pp. 4–6. FAO (I970) https://doi.org/10.1016/S0308-8146(98)00200-3
2. Miceli N, Buongiorno LP, Celi MG, Cacciola F, Dugo P, Donato P, Mondello L, Bonaccorsi I, Taviano MF. Role of the flavonoid-rich fraction in the antioxidant and cytotoxic activities of *Bauhinia forficate* link. (Fabaceae) leaves extract. Nat Product Res. 2016;30(11):1229–39. https://doi.org/10.1080/14786419.2015.1050671.
3. Onwurafor EU, Onweluzo JC, Ezeoke AM. Effect of fermentation methods on chemical and microbial properties of mung bean (*Vigna radiata*) flour. Off J Niger Inst Food Sci Technol. 2014;32(1):89–96.
4. Chandrasiri SD, Liyanage R, Vidanarachchi JK, Weththasinghe P, Jayawardana BC. Does processing have a considérable on the nutritional and fonctional properties of mung bean (*Vigna radiata*). Procedia Food Sci. 2016;6:352–5.
5. Abrahams PW. Geophagy (soil consumption) and iron supplementation in Uganda. Tropical Med Int Health. 1997;2:617–23. https://doi.org/10.1046/j.1365-3156.1997.d01-348.x.
6. Hooda PS, Henry CJK, Seyoum TA, Armstrong LDM, Fowler MB. The potential impact of geophagia on the bioavailability of iron, zinc and calcium in human nutrition. Environ Geochem Health. 2002;24:305–19. https://doi.org/10.1023/A:1020542810334.
7. Imtiaz H, Burhan-Uddin M, Gulzar MA. Evaluation of weaning foods formulated from germinated wheat and mung-bean from Bangladesh. Afr J Food Sci. 2011;5(17):897–903. https://doi.org/10.5897/AJFS11.180.
8. Pataczek L, Zahir ZA, Ahmad M, Rani S, Nair R, Schafleitner R, Cadisch G, Hilger T. Beans with benefits-the role of mung-bean (*Vigna radiata*) in a changing environment. Am J Plant Sci. 2018;9(07):1577–600. https://doi.org/10.4236/ajps.2018.97115.
9. Kabré WJDA, Dah-Nouvlessounon D, Hama F, Kohonou NA, Sina H, Senou M, Savadogo A. Anti-inflammatory and anti-colon cancer activities of mung bean grown in Burkina Faso. Evid-Based Complement Altern Med. 2022. https://doi.org/10.1155/2022/7873572.
10. Kabré WJD, Durand DN, Hama-Ba F, Abiola A, Felix G, Haziz S, Lamine BM. Mung bean (*Vigna radiata* (L.) R. Wilczek) from Burkina Faso used as antidiabetic, antioxidant and antimicrobial agent. Plants. 2022;11(24):3556.
11. INERA Institut de l'Environnement et de Recherches Agricoles (2019) Foire aux Semences de l'INERA, 10ème édition, Ouagadougou 06 au 09 Juin 2019. https://lefaso.net/spip.php?article90090
12. Kabré Wendmintiri Jeanne d'Arc, Fatoumata Hama-Ba, Sibiri NEBIE, Elisabeth Wendmalegda Nikiéma et Aly Savadogo (2022). Etats des lieux de l'évolution de la production et des utilisations du *mung bean* (*Vigna radiata*) au Burkina Faso, Revue semestrielle de la recherche du Centre National de la Recherche Scientifique et Technologique (CNRST), *Science et technique*
13. AFNOR Association Française de Normalisation **(**2000) Détermination de la teneur en eau, méthode pratique. Céréales, Légumineuses, Produits Dérivés NF V 03- 707
14. ISO International Standardization Organization. Détermination de la teneur en matière grasse selon la méthode d'extraction par Soxhlet. ISO. 1998;659:1998.
15. AFNOR Association Française de Normalisation (1970). Directives générales pour le dosage de l'azote avec minéralisation selon la méthode de Kjedahl. Produits Agricoles Alimentaires, NF V 03–050
16. Egan H, Kirk RS, Sawyer R. Pearson's chemical analysis of foods. 8th Edition, Churchill Livingstone, London, New York; 1981. https://doi.org/10.1016/0308-8146(93)90306-Z
17. Atwater WO, Benedict FG. Experiments on the metabolism of matter and energy in the human body. US Department of Agriculture Washington, D.C., Bulletin 1901;69: 112. https://doi.org/10.18697/ajfand.80.17315 12871
18. AOAC Association of Official Analytical Chemists. Official methods for analysis. 16th ed. Arlington VA, USA: Association of official analytical chemists; 1990.
19. Singleton VL, Orthofer R, Lamuela-Raventós RM. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods Enzymol. 1999;299:152–78. https://doi.org/10.1016/S0076-6879(99)99017-1.
20. Latta M, Eskin M. A simple method for phytate determination. J Agric Food Chem. 1980;28:1313–5. https://doi.org/10.1021/jf60232a049.
21. Philips RD, Chinnan MS, Branch AL, Miller J, Mcwatters KH. Effects of pretreatment on functional and nutritional properties of cowpea meal. J Food Sci. 1988;53:805–9. https://doi.org/10.1111/j.1365-2621.1988.tb08959.x.
22. Guezlane L, Abecassis J. Méthodes d'appréciation de la qualité culinaire du couscous de blé dur. Ind Alim Agr. 1991;11:966–71.
23. Mubarak AE. Nutritional composition and antinutritional factors of *mung bean* seeds (*Phaseolus aureus*) as affected by some home traditional processes. Food Chem. 2005;89(4):489–95. https://doi.org/10.1016/j.foodchem.2004.01.007.
24. USDA United States Department of Agriculture (2005) Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory, Beltsville Md, United States. http://www.nal.usda.gov/fnic/foodcomp
25. Khokhar S, PushpanjaliFenwick GR. Phytate content of Indian foods and intakes by vegetarian Indians of Hisar Region, Haryana State. J Agric Food Chem. 1994;42:2440–4. https://doi.org/10.1021/jf00047a014.
26. Sompong U, Kaewprasit C, Nakasathien S, Srinives P. Inheritance of seed phytate in *mung bean* (*Vigna radiata* (L.) Wilczek). Euphytica. 2010;171:389–96. https://doi.org/10.1007/s10681-009-0053-y.
27. Hegazi SM. Effect of germination on the carbohydrate, protein and amino acid contents of broad beans. 1974; 13. https://doi.org/10.1007/BF02021191
28. Hama-Ba F, Siedogo M, Ouedraogo M, Dao A, Dicko H, Diawara B. Modalités de consommation et valeur nutritionnelle des legumineuses alimentaires au Burkina Faso. Afr J Food Agric Nutr Dev. 2017;17(4):12871–88. https://doi.org/10.18697/ajfand.80.17315.
29. Appiah F, Asibuo JY, Kumah P. Physical and functional properties of bean flours of three cowpea (*Vigna unguiculata* L. walp) varieties in Ghana. Afr J Food Sci. 2011;2:100–4.
30. Onwuka GI, Akaerue B. Effect of processing on the proximate composition of the dehulled and undehulled mung bean [*Vigna radiata* (L.). Pak J Nutr. 2010;9(10):1006–16. https://doi.org/10.3923/pjn.2010.1006.1016.
31. El-Adawy TA. Nutritional composition and antinutritional factors of chickpeas (*Cicer arietinum* L.) undergoing different cooking methods and germination Hama-Ban. Plant Food Human Nutr. 2002;57:83–97. https://doi.org/10.1023/a:1013189620528.
32. Xue Z, Wang C, Zhai L, Yu W, Chang H, Kou X, Zhou F. Bioactive compounds and antioxidant activity of mung bean (*Vigna radiata* L.), soybean (*Glycine max* L.) and black bean (*Phaseolus vulgaris* L.) during the germination process. J Food Sci. 2016;34:68–78. https://doi.org/10.17221/434/2015-CJFS.
33. Duong TCT, Duong TPL, Ha TT. The changes in antioxidant capacity of soybean (*Glycine max* (L.) Merrill) and mung bean (*Vigna radiate* (L.) Wilczek) during germination process. Int J Adv Agric Sci Technol. 2016;4:13–21.
34. López A, El-Nagga T, Dueñas M, Ortega T, Estrella I, Hernandez T, Gomez-Serranillos M, Palomino OM, Carretero ME. Effect of cooking and germination on phenolic composition and biological properties of dark beans (*Phaseolus vulgaris* L.). Food Chem. 2013;138:547–55.
35. Hurrell RF, Juillerat MA, Reddy MB, Lynch SR, Dassenko SA, Cook JD. Soy protein, phytates and iron-absorption in humans. Am J Clin Nutr. 1992;56(573):8. https://doi.org/10.1093/ajcn/56.3.573.
36. Saha PR, Weaver CM, Mason AC. Mineral bioavailability in rats from intrinsically labeled whole wheat flour of various phytate levels. J Agric Food Chem. 1994;42:2431–535. https://doi.org/10.1021/jf00047a029.
37. Carcea M, Acquistucci R. Isolation and physicochemical characterization of fonio (*Digitaria exillis* Stapf). Starch-Starch. 1997;49:131–5. https://doi.org/10.1002/star.19970490403.
38. Akissoe N, Hounhouigan J, Mestres C, Nago M. How blanching and drying affect the colour and functional characteristics of yam (*Dioscorea cayenensis-rotundata*) flours. Foods Chem. 2003;82:257–64. https://doi.org/10.1016/S0308-8146(02)00546-0.
39. Khattab RY, Arntfield SD. Nutritional quality of legume seeds as affected by some physical treatments 2. Antinutritional factors. LWT - Food Sci Technol. 2009;42:1113–8. https://doi.org/10.1016/j.lwt.2009.02.004.
40. Yadahally NS, Vadakkoot BS, Vishwas MP, Vasudeva S. Nutrients and antinutrients in cowpea and horse gram flours in comparison to chickpea flour: evaluation of their flour functionality. Food Chem. 2012;131(2):462–8. https://doi.org/10.1016/j.foodchem.2011.09.008.

Publisher's Note