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Effect of Steeping and Sprouting on the Nutritional, Anti-Nutritional and Functional Properties of Pear Millet *(Pennisetum glaucum)* Starch

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ABSTRACT: This study was conducted on the nutritional, anti-nutritional and functional properties of pearl millet starch. Processing methods adopted were steeping and sprouting for the period of 24, 48 and 72 h. The results showed that the processing methods have tremendous effect on the proximate, minerals, anti-nutrients and functional properties of the millet starch. Increase processing period showed significantly ($p<0.05$) higher crude protein, ash, crude fibre, moisture, magnesium, calcium and potassium content but significantly ($p<0.05$) reduced the carbohydrate and antinutrients (phytate and polyphenol) content. Water absorption capacity, fat absorption capacity and bulk density were significantly ($p<0.05$) increased as the processing period increased while gelatinization temperature gradually reduce with advanced in processing period. These properties demonstrate the untapped potential of millet starches for use in food applications.

KEYWORDS: Proximate, Pearl millet, Starch, Functional properties, Period

I. INTRODUCTION

Starch is a semi-crystalline biopolymer and it is stored in various plant locations e.g. cereal, roots, tubers, stem pith, leaves, seeds, fruit and pollens [1]. Starch, the main plant carbohydrate is the most important plant derivative acting as a main energy source in human diet [2]. It has unlimited importance in the food industry and can be modified to suit various applications using low cost methods, making it ideal for a number of uses [3]. Starch is often used as a thickener, emulsion stabilizer, binder and gelling agent. It has a unique property to absorb water and yield gel, if its suspension is heated [4]. The chemical composition, structure and properties of starch are essentially typical of biological origin of the starch [5].

Millets are group of small-seeded species of cereal crops or grains, widely grown as staple food of the millions inhabiting the arid and tropics of the world [6]. Millet ranks as the sixth most important cereal and feeds as third of the total world population [7]. Pearl millet *(Pennisetum glaucum)* is one of the most nutritious cereal grains and it tastes better than most cereal grains, though its enhanced digestibility and biocompatibility is yet to be fully exploited. Pearl millet grains contain various phenolic compounds that have been shown to contribute to its antioxidant properties [8].

Like other cereal grains, the abundance of anti-nutrients such as phytic acid and polyphenols inhibit proteolytic and amylolytic enzymes, limit protein and starch digestibility and make poor human bioavailability of minerals. Anti-nutrients like polyphenols are known to hinder the availability of minerals in grains. These anti-nutrients can be reduced drastically through different processing methods such as steeping, sprouting, cooking, fermentation and toasting. Steeping usually forms an integral part of these processing methods and the media used include water, alkali

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and salt or combination of salts [9]. Sprouting is a process widely used in legumes and cereals to increase their palatability and nutritional value, particularly through the breakdown of certain antinutrients, such as phytate and protease inhibitors [10]. Knowledge on these issues is required so that the potential of pearl millet can be evaluated. Hence, the need to investigate the effect of steeping and sprouting on the proximate composition, mineral content, antinutrient contents and functional properties of millet starch.

II. MATERIALS AND METHODS

Millet grain used for this research work was purchased from Akpan-Andem market in Uyo, Akwa Ibom State. The chemicals used were of analytical grade.

A. Samples Preparation:

Millet grains were sorted, cleaned to remove all extraneous matter and divided into seven (7) equal parts. One (1) portion was steeped overnight and served as control (MSC). Three (3) portions were steeped separately in distilled water for 24, 48 and 72 h with ratio 1:5 (w/v) which were coded as STMA, STMB and STMC, respectively. The steeped water was changed at the interval of 24 h and at the end of each steeping period the steeped water was discarded. The remaining three portions were steeped for 12 h and then sprouted for 24, 48 and 72 h in a manually constructed sprouted box at room temperature and samples were coded as SPMD, SPME and SPMF, respectively. At the end of each steeping and sprouting period including control, the grains were rinsed and wet milled using a plate type grinding mill. This operation was repeated twice for all samples to obtain a fine and clear paste. The paste obtained thereafter was then sieved through a muslin cloth with fine aperture and then allowed to sediment. The starch slurry was subsequently decanted and the starch residue washed three times with clean water. The water remaining after decanting was squeezed out manually forming a cake. The starch cake formed was broken, spread thinly on trays and oven dried at 55 ^{o}C. The dried starch granules were then milled and sieved to obtain fine starch powder and packaged in polyethylene bag on which subsequent analyses were carried out.

B. Chemical Analysis:

Proximate composition (crude protein, crude fat, ash, crude fibre and moisture content) of the millet starch samples was carried out according to the method of [11]. Carbohydrate content calculated as weight by difference between 100 and the summation of other proximate parameters. %Carbohydrate = 100 - (Crude protein + crude fat + ash + crude fibre + moisture). Selected mineral contents (magnesium, calcium, phosphorus and potassium) were determined using the method of [11]. For the determination of each mineral, standards were prepared from the stock solution and were used to calibrate the equipment in concentration mode. The starch sample (2.0 g) was put in a crucible and placed into a muffle furnace, ashed at 550°C for 4 h and then cooled. The ash was washed into a 100 ml volumetric flask with 1% HNO_3, made up to the mark and filtered through a Whatman No. 1 filter paper. The filtered digest was then transferred into the Atomic Absorption Spectrophotometer (AAS) auto sampler vial and used directly for the determination of magnesium and calcium by the Atomic Absorption Spectrophotometer (UNICAM, Model 939, UK). Phosphorus was analysed using vanado-molybdate method and potassium was determined using the standard flame emission photometer. Selected anti-nutrients content determined were phytate and polyphenol. Phytate content was determined using spectrophotometric method as described by [12] and total polyphenol was determined using Prussian blue spectrophotometric method by [13]. Selected functional properties such as gelation temperature and bulk density were determined using the method described by [14] and water and oil absorption capacity were carried out using the method described by [15].

C. Statistical Analysis:

Each sample was analysed in triplicates and the mean data±SD (Standard Deviation) are reported. Data obtained were subjected to analysis of Variance (ANOVA) using SPSS version 20. Means were compared by using Duncan New Multiple Range Test (DNMRT) and $p<0.05$ was applied to establish significant difference.

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III. RESULTS AND DISCUSSION

A. Proximate Composition of Steeped and Sprouted Millet Starch:

Table 1 shows the result of proximate composition of steeped and sprouted millet starches obtained from different periods. There were significant ($p<0.05$) differences in all the measured parameters. The protein content of the millet starch ranged from 1.90 to 2.62%. 72 h steeped millet starch (STMC) had the highest value while control (MSC) had the least value. Protein content reported for the steeped and sprouted millet starches were slightly lower than the range (3.2- 3.4%) reported by [16] for traditionally extracted pearl millet starches but higher than the reports of [17]. Increase in protein content may be attributed to biological synthesis of new amino acids during sprouting [18]. The fat contents of the starch samples were generally high, ranging from 3.84 to 4.27% for 24 h steeped starch (STMA) and MSC. Steeping and sprouting processes were observed to significantly ($p<0.05$) reduced the value of STMA and 24 h sprouted millet starch (SPMD) when compared with MSC. Values obtained in this study are not conformed with the report of [19] who reported an increase in fat content of sprouted sorghum but agree with the findings of [20] who reported a decrease in fat content of maize starch as malting period increased. The higher fat content of the millet starch could be attributed to the presence of free fatty acids reacting with other products of hydrolysis [19]. The ash contents of the starches ranged from 0.22 to 0.42% for STMA and STMC, respectively. Results obtained are lower than the values of modified starches reported by [4]. The crude fibre content of the starches ranged from 0.04 to 0.10% with the highest value observed in the 72 h sprouted millet starch (SPMF). The values obtained agree with the reports of [16] who found out that the crude fibre content of traditionally extracted pearl millet starch reduced during fermentation. The moisture contents of the millet starches were very low which ranged from 3.45 to 7.84%. No significant ($p>0.05$) differences were observed among the MSC, STMA and SPMD. The moisture level of the starch samples was within the recommended moisture levels for safe storage. These values were low enough for adequate shelf-life stability if packaged in moisture-proof containers [21]. However, low moisture content of food samples is a desirable phenomenon because it helps to reduce microbial activities in the food sample. Significant ($p<0.05$) reduction was observed in the carbohydrate contents of the starch samples. At 24 h of steeping and sprouting, values increased to 90.45 and 90.20%, respectively, when compared with MSC. The values later gradually reduced at 48 and 72 h of steeping and sprouting. The values obtained were slightly higher but comparable with the maize starch reported by [20]. Decrease in the carbohydrate content of sprouted millet starch may be due to the utilization of some of the sugars during the growth metabolic activity.

Table 1: Proximate composition (%) of steeped and sprouted millet starch

Sample code	Crude protein	Crude fat	Ash	Crude fibre	Moisture	Carbohydrate
MSC	$1.90^{e}\pm0.04$	$4.27^{a}\pm0.05$	$0.41^{a}\pm0.11$	$0.09^{ab}\pm0.02$	$3.45^{d}\pm0.22$	$89.85^{ab}\pm0.93$
STMA	$1.95^{de}\pm0.05$	$3.84^{e}\pm0.05$	$0.22^{c}\pm0.03$	$0.06^{bc}\pm0.01$	$3.48^{d}\pm0.15$	$90.45^{a}\pm5.64$
STMB	$2.04^{cd}\pm0.04$	$3.98^{cd}\pm0.03$	$0.35^{abc}\pm0.13$	$0.08^{ab}\pm0.01$	$6.04^{b}\pm0.18$	$87.51^{b}\pm0.25$
STMC	$2.62^{a}\pm0.02$	$4.08^{b}\pm0.07$	$0.42^{a}\pm0.04$	$0.09^{ab}\pm0.01$	$7.84^{a}\pm0.15$	$84.95^{c}\pm0.17$
SPMD	$2.11^{c}\pm0.09$	$3.94^{d}\pm0.04$	$0.26^{bc}\pm0.03$	$0.04^{c}\pm0.01$	$3.48^{d}\pm0.17$	$90.20^{a}\pm0.22$
SPME	$2.15^{c}\pm0.13$	$4.04^{bc}\pm0.06$	$0.33^{abc}\pm0.05$	$0.07^{abc}\pm0.01$	$4.51^{c}\pm0.34$	$88.90^{ab}\pm0.25$
SPMF	$2.49^{b}\pm0.05$	$4.07^{b}\pm0.03$	$0.36^{ab}\pm0.05$	$0.10^{a}\pm0.03$	$7.71^{a}\pm0.16$	$85.27^{bc}\pm0.49$

Values are mean ± SD of triplicate determination. Mean values followed by different superscript within the

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same column are significantly ($p<0.05$) different. Key: MSC=millet starch control sample, STMA=24 h steeped millet starch, STMB=48 h steeped millet starch, STMC=72 h steeped millet starch, SPMD=24 h sprouted millet starch, SPME=48 h sprouted millet starch, SPMF=72 h sprouted millet starch

B. Mineral Content of Steeped and Sprouted Millet Starch:

The result of the selected mineral content of millet starch obtained using different steeping and sprouting period intervals is shown in Table 2. Significant ($p<0.05$) differences were observed in the entire mineral content determined. All the selected mineral contents analysed in the millet starches followed the same increasing trend from 48 to 72 h of steeping and sprouting. Minerals are critically important to the human health maintenance as they are essential for the body's many biochemical processes [22]. Magnesium ranged from 36.50 to 60.37 mg/100g for SPMD and STMC, respectively.

Table 2: Mineral contents (mg/100g) of steeped and sprouted millet starch

Sample code	Magnesium	Calcium	Phosphorus	Potassium
MSC	$39.00^{d}\pm1.00$	$101.63^{d}\pm4.01$	$1.39^{bc}\pm0.01$	$13.30^{b}\pm1.13$
STMA	$38.53^{d}\pm0.42$	$95.37^{e}\pm1.18$	$1.17^{d}\pm0.04$	$11.93^{c}\pm0.07$
STMB	$49.33^{b}\pm0.57$	$124.13^{b}\pm2.01$	$1.34^{c}\pm0.06$	$13.44^{b}\pm0.55$
STMC	$60.37^{a}\pm0.55$	$132.27^{a}\pm2.20$	$1.39^{bc}\pm0.02$	$15.23^{a}\pm0.19$
SPMD	$36.50^{e}\pm0.50$	$91.83^{e}\pm1.18$	$1.35^{c}\pm0.03$	$8.61^{e}\pm0.37$
SPME	$42.00^{c}\pm2.26$	$103.87^{d}\pm5.31$	$1.44^{b}\pm0.04$	$9.90^{d}\pm0.11$
SPMF	$42.40^{c}\pm1.00$	$110.10^{c}\pm0.30$	$1.56^{a}\pm0.05$	$10.67^{d}\pm0.57$

Values are mean ± SD of triplicate determination. Mean values followed by different superscript within the same column are significantly ($p<0.05$) different. Key: MSC=millet starch control sample, STMA=24 h steeped millet starch, STMB=48 h steeped millet starch, STMC=72 h steeped millet starch, SPMD=24 h sprouted millet starch, SPME=48 h sprouted millet starch, SPMF=72 h sprouted millet starch

The results fall in range with the values obtained by [23] on mineral contents of 10 pearl millet genotypes. Calcium content ranged from 91.83 to 132.27 mg/100g with STMC having the highest content. The values obtained in this study were higher than those reported by [24]. Phosphorus content ranged between 1.17 mg/100g (STMA) and 1.56 mg/100g (SPMF). The potassium content ranged between 8.61 and 15.23 mg/100g. The values obtain are comparable to pearl millet starch obtained from Ashana (13.27mg/100g) and Dembi (13.36mg/100g) as reported by [16]. [25] also observed an increase in mineral content in oat and barley during germination.

C. Antinutritional Content of Steeped and Sprouted Millet Starch:

The results of selected antinutrients (phytate and polyphenol) of the millet starches ranged between 1.48 to 5.87 mg/100g for phytate and 12.18 to 25.02 mg/100g for polyphenol (Table 4). There were significant ($p<0.05$) differences in all the measured parameters as it showed a decrease in the antinutrients content with increasing period of steeping and sprouting. The least phytate and polyphenol contents were observed in STMC. Values obtain from this study agree with the reports of [24] but lower than the value reported for cooked millet by [26]). Decrease in antinutritional factors during steeping and sprouting could be attributed to leaching of polyphenols in soaking water and increased enzymatic treatment during germination [9,27].

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Table 3: Antinutritional contents (mg/100g) of steeped and sprouted millet starch

	MSC	STMA	STMB	STMC	SPMD	SPME	SPMF
Phytate	$3.49^{b}\pm0.12$	$2.93^{c}\pm0.06$	$2.36^{d}\pm0.09$	$1.48^{f}\pm0.01$	$5.87^{a}\pm0.01$	$2.95^{c}\pm0.06$	$1.62^{e}\pm0.02$
Polyphenol	$21.17^{c}\pm0.30$	$26.01^{a}\pm0.04$	$16.87^{e}\pm0.35$	$12.18^{f}\pm0.34$	$25.02^{b}\pm0.02$	$17.34^{d}\pm0.04$	$17.12^{de}\pm0.07$

Values are mean ± SD of triplicate determination. Mean values followed by different superscript within the same column are significantly (p<0.05) different. Key: MSC=millet starch control sample, STMA=24 h steeped millet starch, STMB=48 h steeped millet starch, STMC=72 h steeped millet starch, SPMD=24 h sprouted millet starch, SPME=48 h sprouted millet starch, SPMF=72 h sprouted millet starch

D. Functional Properties of Steeped and Sprouted Millet Starch:

The result of selected functional properties of millet starches produced via varying steeping and sprouting period intervals is shown in Table 4.

Table 4: Functional properties of steeped and sprouted millet

Sample code	Gelatinization temp (˚C)	Bulk Density (g/ml)	Water absorption capacity (ml/g)	Oil absorption capacity (g/g)
MSC	$76.33^{a}\pm1.53$	$0.56^{d}\pm0.05$	$1.40^{d}\pm0.02$	$1.64^{f}\pm0.05$
STMA	$69.33^{b}\pm1.15$	$0.76^{a}\pm0.05$	$2.42^{c}\pm0.17$	$2.21^{e}\pm0.01$
STMB	$64.33^{c}\pm4.04$	$0.75^{a}\pm0.04$	$2.62^{b}\pm0.03$	$2.31^{d}\pm0.03$
STMC	$63.00^{c}\pm2.65$	$0.73^{ab}\pm0.03$	$2.68^{ab}\pm0.01$	$2.32^{d}\pm0.01$
SPMD	$71.67^{b}\pm1.53$	$0.66^{bc}\pm0.07$	$2.73^{ab}\pm0.04$	$2.39^{c}\pm0.02$
SPME	$71.00^{b}\pm1.00$	$0.61^{cd}\pm0.03$	$2.74^{ab}\pm0.03$	$2.47^{b}\pm0.01$
SPMF	$70.52^{b}\pm2.31$	$0.60^{cd}\pm0.05$	$2.78^{a}\pm0.04$	$2.57^{a}\pm0.05$

Values are mean ± SD of triplicate determination. Mean values followed by different superscript within the same column are significantly (p<0.05) different. Key: MSC=millet starch control sample, STMA=24 h steeped millet starch, STMB=48 h steeped millet starch, STMC=72 h steeped millet starch, SPMD=24 h sprouted millet starch, SPME=48 h sprouted millet starch, SPMF=72 h sprouted millet starch

The gelatinization temperature showed a significant reduction (p<0.05) with increase period of steeping and sprouting. The values ranged from 63.00 to 76.33 ºC with MSC having the highest gel temperature of 76.33 ºC. Present observations are in line with the findings of [16] who found that traditionally extracted pearl millet starch *Jir* has gelatinization temperatures range from 60 to 70 ºC. The bulk density of the millet starches ranged from 0.56 to 0.76 g/ml. STMA had the highest value while MSC had the least value. There was no significant (p>0.05) difference between STMA and STMB. The bulk density is a reflection of the load the starch samples can carry, if allowed to rest directly on one another and low value is a good physical attribute when determining transportation and storability. [28,29]. Results obtained compared well with the values reported by [30]. The water absorption capacity ranged from 1.40 to 2.78 ml/g. The higher the steeping and sprouting time, the higher the water absorption capacity of the millet starches. Values obtained were comparable with the observations of [16]. Similar results were reported for yellow and white maize varieties [31]. Similar trend was observed in the oil absorption capacity. It ranged from 1.64 to 2.57 g/g, with STMCF having the highest value of 2.57 g/g. Steeping significantly (p<0.05) increased oil absorption capacity of

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the millet starch. The observations were in line with the findings of [32] who found that fat absorption capacity vary from 0.55 to 2.7 g/g for pearl millet flour and their products.

IV. CONCLUSION

Differences in starch proximate composition, mineral content, antinutrients and functional properties were observed in this study as was expected with distinctive properties for the steeped and sprouted starches compared to the control sample. Sprouting has been found to significantly increased the crude protein and crude fibre content. Steeping increase ash content of millet starches and greatly contributed to higher magnesium, calcium and potassium content. Availability of these minerals were as a result of decreasing trend in the antinutrients (phytate and polyphenol) content of the millet starch. The processing methods resulted in low gelation temperature and bulk density, increased water absorption capacity and oil absorption capacity. Hence, this information would be of use in food systems where the functional properties are required especially in infant food formulations.

REFERENCES

[1]. L Jayakody and R. Hoover, "Effect of annealing on the molecular structure and physiochemical properties of starches from different botanical origins: a review of carbohydrate polymers," no. 74, 2008, pp. 691-703.
[2]. R. B. Yadav, N. Kumar, and B. S. Yadav, "Characterization of banana, potato, and rice starch blends for their physicochemical and pasting properties," Cogent Food & Agriculture, no. 2, 2016, pp. 1127873.
[3]. P. H. Yiu et al., "Physicochemical properties of sago starch modified by acid treatment in alcohol," Am. J. Appl. Sci., no. 5, 2008, pp. 307-311.
[4]. S. Balasubramanian et al., "Isolation, modification and characterization of finger millet (*Eleucine coracana*) starch. Journal of Food Science and Engineering, no.1, 2011, pp. 339-347.
[5]. A. M. Smith, "The biosynthesis of the starch granule," Biomacromolecules, no. 2, 2011, pp. 335-341.
[6]. K. B. Odusola, F. F. Ilesanmi, and O. A. Akinloye, "Assessment of nutritional composition and antioxidant ability of pearl millet (*Pennisetum glaucum*)," American Journal of Research Communication, vol.1, no. 6, 2013: pp. 262-272.
[7]. A. S. M. Saleh et al., "Millet grains: nutritional quality, processing, and potential health benefits," Comprehensive Reviews in Food Science and Food Safety, no. 12, 2013, pp. 281-295.
[8] L. Dykes and L. W. Rooney, "Sorghum and millet phenols and antioxidants. Journal of Cereal Science," vol. 44, no. 1, 2006, pp. 236–251.
[9]. O. B. Ocheme and E. G. Mikailu, "Effect of alkaline soaking and cooking on the proximate, functional and some anti-nutritional properties of sorghum flour," AU J.T., vol. 14, no. 3, 2011, pp. 210-216.
[10]. A. M. R. Afify et al., "Bioavailability of iron, zinc, phytate and phytase activity during soaking and germination of white sorghum varieties," Plos One, vol. 6, no. 10, pp. e25512.
[11]. AOAC, "Official method of analysis (18th edition.). Association of Official Analytical Chemists," Washington DC., USA, 2005.
[12]. D. Pearson, "The Chemical Analysis of Foods. 7th Edition, London," Churchill Livingstone, 1976.
[13]. M. L. Price and L. G. Butler, "Rapid visual estimation and spectrophotometric determination of tannin content of sorghum grain," Journal of Agriculture and Food Chemistry, no. 25, 1977, pp. 1268-1273.
[14]. G. I. Onwuka, "Food analysis and instrumentation: theory and practice," Naphthali Publishers Ltd, Lagos, Nigeria, 2005, pp. 56-62.
[15]. B. W. Abbey and G. O. Ibeh, "Functional properties of raw and heat processed cowpea flour," Journal of Food Science and Technology, no. 53, 1998, pp. 1775-1777.
[16]. A. A. Abdalla et al., "Physicochemical characterization of traditionally extracted pearl millet starch (*Jir*). Journal of Applied Sciences Research, vol. 5, no. 11, 2009, pp. 2016-2027.
[17]. M. L. Bangoura, et al., "Starch functional properties and resistant starch from foxtail millet (*Setaria italica* (L.) P. Beauv) species. Pakistan Journal of Nutrition, vol. 11, no. 10, 2012, pp. 919-928.
[18]. S. Mbithi-Mwikya et al., "Nutrient and antinutrient changes in finger millet (*Eleusine coracan*) during sprouting," Lebensm LWT-Food Science and Technology, no. 33, 2000, pp.9-14.
[19]. I. E. Mbaeyi and J. C. Onweluzo, "Effect of sprouting and pre-gelatinization on the physicochemical properties of sorghum-pigeon pea composite blend used for the production of breakfast cereal," Journal of Tropical Agriculture, Food, Environment and Extension, vol. 9, no. 1, 2010, pp. 8-17.
[20]. O. L. Otutu, D. S. Ikuomola, and R. O. Oloruntoba, "Effect of sprouting days on the chemical and physicochemical properties of maize starch," American Journal of Research Communication, vol. 2, no. 6, 2014, pp. 131-149.
[21]. Y. E. Alozie et al., "Utilization of bambara ground flour blends in bread production. J. Food Technol., vol. 7, no. 4, 2009, pp. 111-114.
[22]. F. A. Bello and A. A. Badejo, "Combined Effects of packaging film and temperatures on the nutritional composition of stored fresh maize (Zea mays) on the cob," American Journal of Food Science and Technology, vol. 5, no. 1, 2017, pp. 23-30.
[23]. A. A. Abdalla et al., "Proximate composition, starch, phytate and mineral contents of 10 pearl millet genotypes," Journal of Food Chemistry, no. 63, 1998, pp. 243 – 246.
[24]. M. A. Samia et al., "Antinutritional factors content and minerals availability of pearl millet (*Pennisetum glaucum*) as influenced by domestic processing methods and cultivar," Journal of Food Technology, vol. 3, no. 3, 2005, pp. 397 – 403.
[25]. F. Hübner et al., "The influence of germination conditions on beta-glucan, dietary fibre and phytate during the germination of oats and barley," European Food Research Technology, no. 231, 2010, pp. 27–35.
[26]. A. A. M. Nouret al., "Supplementation and cooking of pearl millet: changes in anti-nutrients, and total minerals content and extractability," Innovative Romanian Food Biotechnology, no. 15, 2014, pp. 9-22.

[27]. M. M. Kindiki, A. Onyango, and F. Kyalo, "Effects of processing on nutritional and sensory quality of pearl millet flour," Food Science and Quality Management, no. 42, 2015, pp. 13-19.

[28] O. S. Fasasi, "Proximate antinutritional factors and functional properties of processed pearl millet (*Pennisetum Glaucum*)," Journal Food Technology, vol. 7, no. 3, 2009, pp. 92-97.

[29]. O. O. Awolu, O. V. Oyebanji, and M. A. Sodipo, "Optimization of proximate composition and functional properties of composite flours consisting wheat, cocoyam (*Colocasia esculenta*) and bambara groundnut (*Vigna subterranea*)," International Food Research Journal, vol. 24, no. 1, 2017, pp. 268-274.

[30]. S. Balasubramanian et al., "Characterization of modified pearl millet (*Pennisetum typhoides*) starch," J Food Sci Technol., vol. 51, no. 2, 2014, pp. 294–300.

[31]. M. O. Adegunwa, L. O. Sanni, and B. Maziya-Dixon, "Effects of fermentation length and varieties on the pasting properties of sour cassava starch," African Journal of Biotechnology, vol. 10, no. 42, 2011, pp. 8428-8433.

[32]. P. I. Akubor and J. E. Obiegbuna, "Certain chemical and functional properties of ungerminated and germinated millet flour," Journal of Food Science and Technology, vol. 36, no. 30, 1999, pp. 241-243.