

Parboiling Effect on Phytate Contains of Two Senegalese Pearl Millet Varieties (*pennisetum glaucum* [L.] R.Br.) GB 87-35 and ICRITABI

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Abstract

Millet (*Pennisetum glaucum*) is a rich source of nutrients compared to other cereal crops. However, its use is limited by the presence of anti-nutritional factors including phytates that reduce the availability of minerals. Thus, several treatment methods have been used to reduce these antinutritional factors. However, our study investigated the effect of parboiling on the phytate concentrations of two varieties of millet GB 87-35 and ICRITABI in Senegal. These two varieties of pearl millet contain 981.82 and 928.71 mg / 100g of phytates, respectively and were comparable to other cereals. The results revealed that for the GB 87-35 millet variety, phytate content varied from 795.88 mg / 100g for unparboiled and decorticated millet to 531.28; 511.614 and 483.60 mg / 100 g, respectively for parboiled and decorticated millets at 60 and 70 and 80 °C. As for the ICRITABI variety, the phytate concentrations are 791.40 mg / 100g for unparboiled and decorticated millet, 656.58 mg / 100g for parboiled and decorticated millet at 60 °C; 567.08 mg / 100g for parboiled and decorticated millet at 70 °C and 526.48 mg / 100 g for parboiled and decorticated millet at 80 °C. Thus, parboiling including hot soaking, steaming and drying before milling resulted in a decrease in the phytate content of two varieties of millet and 80 °C would be the best soaking temperature for a significant ($p < 0.05$) reduction phytate concentrations. Parboiling can become one of the efficace methods of technological treatment used to reduce phytates in millet grains.

Keywords: Pearl mil (*Pennisetum glaucum*); phytates; decorticate; parboiling;

Introduction

Pearl millet (*Pennisetum glaucum*) is a staple food in arid and semi-arid areas of Africa and Asia. It has capability to survive under drought and high temperature conditions and low soil fertility. The millet crop ranks in fourth of the world tropical food cereal grains. Millet grains like other food bring to human life the necessary nutritives substances such as proteins, lipids, carbohydrates, vitamins and mineral elements [1, 2, 3]. Essential amino acid profile revealed that pearl millet is 40% richer in lysine and methionine and 30% richer in threonine than in

protein of corn [4]. The presence of all required nutrients in pearl millet makes it suitable for large-scale utilization in the manufacture of various food products such as baby foods, snack foods, dietary foods in both grain and flour form. In addition to the nutritional benefits, pearl millet also provide products certain phytochemicals with antinutrient effect.

In addition to this nutrient richness, millet also provide products with no nutritional value but often useful as pectins and cellulose and even toxic substances undesirable to the human body and inhibitors of the assimilation of nutrients called antinutritional factors (ANF) [5, 6, 7]. These can be classified into two categories: those that occur naturally in grains and those that are due to contamination that may be of fungal origin and/or soil related origin or other environmental factors. Anti-nutritional factors limited the nutritional quality of the grains by leading to a marked reduction in bioavailability of some nutrients and this can have very serious consequences on the health of consumers [8, 9]. They include polyphenols and tannin, oxalic acid and phytic acid or phytates [10].

Pearl millet contains significant amounts of inositol hexaphosphates (IP6) generally referred to as phytic acid or phytate. Phytic acid (myo-inositol 1, 2, 3, 4, 5, 6-hexakis phosphate) is a hexaphosphate ester inositol, has long been known as form of stored phosphors in seeds and grains.

Phytates (phytic acid salts) represent a category of natural compounds that can have a significant influence on the functional and nutritional properties of foods of plant origin. Phytate has long been recognized as an antinutritional factor affecting the bioavailability of major minerals such as Ca and P and trace elements such as Zn, Fe, Cu and Mn. Phytates also affect the nutritional value of the grain by inhibiting protein and starch digestibility and mineral bioavailability. In fact, decreasing of phytic acid is very advantageous, due to its influence on nutrition;

therefore interest has grown to reduce its antinutritional effects [11]. Several methods have been employed to improve the nutritional quality of cereals. Thus, [12, 13, 14] reported that the important traditional methods used to reduce antinutrients and improve the bioavailability of minerals were: soaking, dehulling, cooking, germination and fermentation.

Parboiling also is one of the technological treatments including hot water soaking, steaming and drying before dehulling. This is the most important operation with the potential to improve dehulling efficiency as well as the nutritional quality of the finished product [15, 16, 17, 18, 19, 20]. The information on parboiling millet is limited and only reported for little millet grains by Mannuramath (2015) [21]. However, no studies have been conducted on the effects of this process on the antinutritional factors of pearl millet. Thus the objective of this study was to investigate the effect of parboiling on the phytate contents of two varieties of Senegalese pearl millet (*Pennisetum glaucum*) GB 87-35 and ICRI-TABI.

Material And Methods

Millet material

Grain samples of two local pearl millet cultivars (GB 87-35 and ICRI-TABI), were used in this study. GB 87-35 and ICRI-TABI pearl millet are among the most common varieties in Senegal. They were obtained from the National Center for Agronomic Research (CNRA) in Bambey, Senegal. The grains were cleaned to remove stones and other impurities in vibrating screen, packed in barrel and stored in ambient conditions for further studies. The tests of parboiling millet were carried out at the « Atelier Céréales et Légumineuses » and analysis on the phytate contents at the « laboratoire de Chimie » of the « Institut de Technologie Alimentaire (ITA) »

Millet parboiling process

Parboiling process was carried out in 4 steps and all treatments were done in triplicates.

➤ Soaking

For each test, 7 kg of whole millet grains were initially soaked in 10.5 L of water using a kettle for 4 hours with increasing temperatures of 60, 70 and 80 °C. After soaking, the grains were cooled at room temperature in covered kettle.

➤ Pre-drying

The steamed paddy was dried in the sun for 1 hours to reduce the amount of water to speed up the process of gelatinization during the steaming step.

➤ Steaming

The soaked grains were steamed using the parboiling system, consisting of a container in form of a bucket, bottom and bottom quarter of the perimeter of which are perforated and surmounted by a kettle made of cast aluminum. The steaming time was fifteen (15) minutes.

➤ Drying

The steamed paddy was firstly dried in the sun for 1 hours. Drying was completed in the shade for 3 days before the husking process. Moisture was determined using the moisture meter and residual moisture between 10 and 12% was obtained.

➤ Milling/Decortication

This operation was carried out by the dry method using a traditional hulling machine. The abrasive discs, rotating at 1300 rpm, produce friction against the mass of grains in motion an abrasion of the outer layers. The residence time of the grains in the dehulling chamber is three (3) minutes, the time required to obtain a sufficiently decorticated grain. The decorticated grains are separated from the bran in the separation chamber through a sieve of mesh 1 mm in diameter.

After dehulling, 200 g of each hulled sample and 200 g of the unparboiled and undecorticated millet for each variety were taken, ground and kept refrigerated for the phytates analysis.

Determination of phytates contents

The phytate contents was determined according to the method described by Latta and Eskin(1980) [22] and Vaintraub et al. (1988) [23].

Statistical analyzes

For this study, all experiments were done in triplicates. The mean ± standard deviation calculations and graphs were performed with Excel 2013 table. The statistical analyzes were performed with XL-STAT 6.1.9 software. The data obtained were subjected by one-way analysis of variance (ANOVA) and the means were compared by the Fisher test at 5% significance level.

Results And Discussion

The phytate contents of unparboiled undecorticated; unparboiled decorticated and parboiled decorticated, millet grains for GB 87-35 and ICRI-TABI varieties were presented in (figure1, figure 2 and figure 3).

The phytate contents of unparboiled undecorticated millet grains were found to be 981.82 and 928.71 mg / 100g for GB 87-35 and ICRI-TABI cultivars, respectively, and were significantly different from each other. These values were similar to those of cereals grains ranged from 0.5 to 1.9% [24]. Results obtained were also within the range reported by Elhage et al. (2002) [25] 943 and 1076 mg / 100 g phytates contents for two pearl millet cultivars and near to value 969.30 - 1101 mg / 100 g reported by Abdelrahman et al. (2005) [11] for two pearl millet cultivars. In a study conducted on ten pearl millet cultivars, Abdalla et al. (1998) [26] reported a large variation of phytate contents 354-795 mg / 100g, which reflecting a strong varietal effect. Simwemba et al. (1984) [27] determined the phytate contents of different genotypes grown in two different geographical areas. They observed levels ranging from 0.18 to 0.27 g / 100 g in the

II. 1. Phytates contents of unparboiled and undecorticated millet grains GB 87-35 and ICRI-TABI varieties

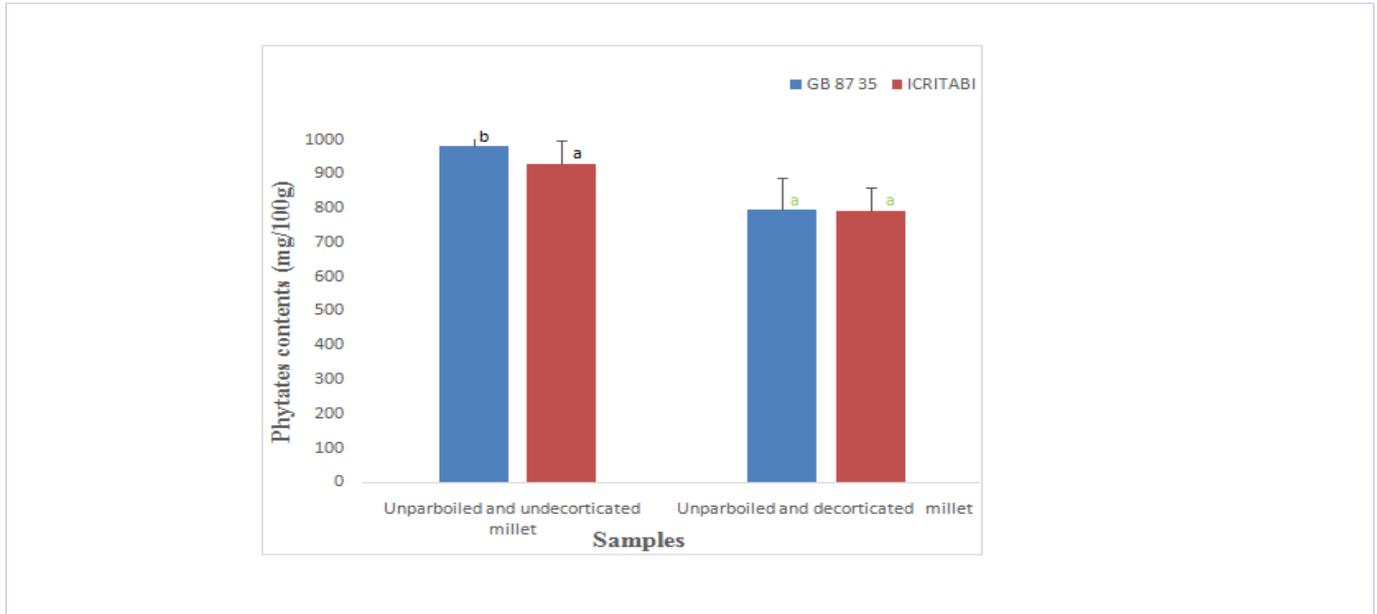


Figure 1: Phytates contents of unparboiled and undecorticated millet and unparboiled decorticated millet grains for GB 87-35 and ICRI-TABI varieties. Means with different letters on the same type of sample are significantly ($P < 0.05$) different.

II. 2. Effect of decortigeage on phytates content

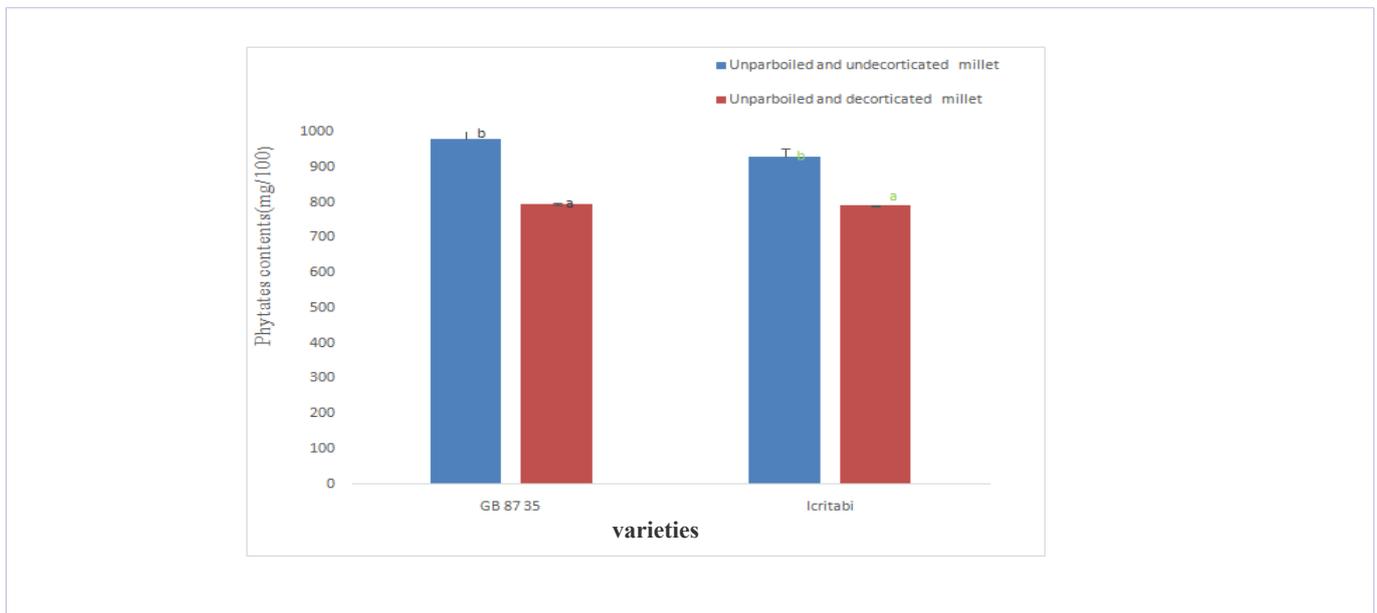


Figure 2: Effect of dehulling on phytate contents for GB 87-35 and ICRI-TABI varieties. Means with different letters on the same varieties are significantly ($P < 0.05$) different.

I. 3. Effect of parboiling on phytates content

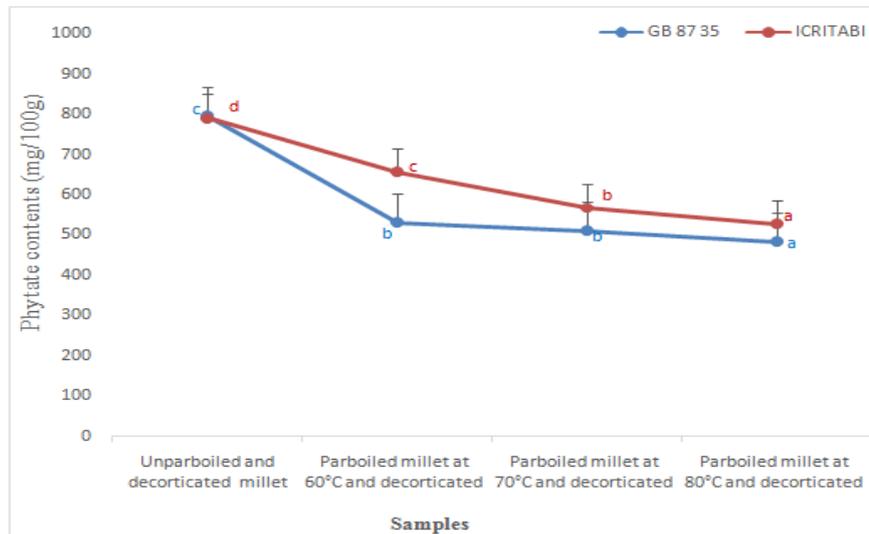


Figure 3: Effect of parboiling on phytate contents for GB 87-35 and ICRI-TABI varieties Means with the different letters on the same variety are significantly ($P < 0.05$) different.

first zone and from 0.21 to 0.31 g / 100 g in the second zone, thus may be due to the impact of genetic and environmental factors. However, the significant difference in phytate contents reported by Abdalla et al. (1998) [26] and Simwemba et al. (1984) [27] could be attributed to the methods. This may also be attribute to the fact that the phytic acid content varies from one variety to another, according to the irrigation conditions and soil nature where it were grown. Thus, in this study, the significant difference observed in cultivars may be attributed to the influence of environmental and genetic conditions as reported by Simwemba et al. (1984) [27].

Phytate concentrations of raw millet grains to decorticated millet decreased from 981.81 to 795.88 mg / 100g for GB 87-35 and from 981.82 to 791.40 mg / 100g for ICRITABI. Decortication of pearl millet grains decreased significantly ($P < 0.05$) phytates contents and samples decorticated were significant diferent. Results obtained were in agreement with those reported by Monawar (1983) [28] and Elhag et al. (2002) [25] who found that phytate contents of millet grains was significantly decreased during dehulling.

In cereals grains, polyphenols and phytates are mainly concentrated in the pericarp, seed coat and aleurone layer [29, 30]. Thus, [31, 32] reported that iron and / or zinc chelators, particularly phytates, were localized in the germ (corn, millet) and / or peripheral tissues. Similar results were observed with Suma et Urooj (2011) [33] in a study of pearl millet, where phytate contents is mainly concentrated in the bran layer. Hama et al. (2011) [34] found that the most amount of the phytates of

millet grains was located in the peripheral parts of the grain.

Decortilage consists to remove completely the layers of pericarp and testa from the grain, with minimal loss of endosperm and germ [35, 36], So that the concentration of phytates is drastically reduced during dehulling.

Thus, authors like [37] reported that dehulling cereals significantly reduces the anti-nutritional factors of the finished product by separating starchy albumen from tissues rich in phytates, phenolic compounds, or fiber.

According to Lehrfeld (1989) [38], during dehulling endogenous phytase comes into contact with phytic acid, and hydrolysis under other forms of inositol phosphate, which allows the reduction of phytate contents.

Phytate content of parboiled millet ranged from 531.28 to 483.60 mg / 100 g for GB 87-35 and 656.58 to 526.48 mg / 100 g for ICRITABI. These values were significantly lower than those of unparboiling decorticated phytate contents of pearl millet 795.88 mg / 100g for GB 87-35 and 791.40 mg / 100g for ICRITABI. From these results, it is clear that all parboiled millets have significantly lower phytate concentrations (≤ 656.58 mg / 100g) than unparboiled and decorticated millet (≥ 791.40 mg / 100g). Consequently, it may be considered that parboiling would result in decrease of phytate content of the millet grains for two varieties.

There is no significant difference on phytate contents of parboiled decorticated millets at 60 and 70 ° C with 531.28 and

511.614 mg / 100g respectively for GB 87-35 variety. These phytate concentrations were significantly higher than 483.60 mg / 100g obtained at 80 °C. As for ICRITABI variety, phytate contents of all parboiled decorticated millets were statistically different and decreased at higher soaking temperature. From this analysis we observed that soaking temperature had significant influence on the phytate contents.

Cereals and legume grains are protected by more or less rigid and impervious envelopes. Soaking is often used as a grain pre-treatment, to facilitate their transformation by allowing better elimination of these envelopes and a tenderness of the grains. During soaking, there is material transfer take place between the food compartment and the soaking water: a part of the minerals elements diffuses into the surrounding environment [39] as well as the activators and / or bioavailability inhibitors [12]. This leaching depends on location and solubility of different constituents, concentration gradient between the material and the environment, and duration of soaking [40]. Previous studies showed that soaking whole grains for longer durations decreased phytic acid content by 20 to 30% [41, 42, 43].

Alonos et al. (2000) [44] reported that soaking in water reduced significantly phytic acid content of faba bean seeds. The reduction of phytic acid during soaking could be attributed to leaching out in soaking water under concentration gradient [45].

The leaching of phytates seems to be favored by the increase of temperature of soaking water, which can increase the activity of phytases. This is the case of ICRITABI variety whose concentrations decrease from 656.58 to 526.48 mg / 100g, respectively with an increase in the soaking temperature of 60 to 80° C. According to Duhan et al. (2002) [40], the soaking temperature is an important parameter for endogenous enzymatic activities (phytases, oxidases) and speed of water penetration into the grain. Thus, with GB 87-35 variety, the phytate content of parboiled and decorticated samples decreased beyond at 70° C to be 483.60 mg / 100g at 80° C. However, the soaking temperature of the medium plays an important role for the degradation of phytic acid to inorganic phosphates [46, 43].

Thus, [47] reported that during processes of grain processing into food products, endogenous and exogenous phytases or transformation conditions can cause significant hydrolysis of myo-inositol hexaphosphate (IP6) to inorganic phosphorus. (IP) and myo-inositol phosphates (IP5 to IP1), resulting in a decrease in phytate contents. Processing methods decreased significantly ($P < 0.05$) phytate contents.

Conclusion

Pearl millet occupies an important place in diet of African peoples. This cereale like others, is rich also nutrients and antinutritional factors, especially phytates. Parboiling, a technological process including hot soaking, steaming and

drying, is used to improve the milling efficiency and nutritional quality of the finished product. On the results of our study, GB 87-35 and ICRITABI varieties are comparable phytate contents to other cereals. This study showed also that parboiling is a way of reducing the phytates content. Phytate concentrations decreased with increasing soaking temperature and 80°C would be the soaking temperature for significant ($P < 0.05$) reduction phytate contents reduction. Parboiling can become one of the efficace methods of technological treatment used to reduce phytates in millet grains.

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