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Determination of Mineral Content and Effect of Parboiling on Phytate Contents of Sahel 108, Sahel 328 and Sahel 329 Rice Varieties Grown in the Senegal River Valley

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Abstract The purpose of this study was to determine the mineral contents (Fe, Ca, P, K) and to study the effect of parboiling on the phytate contents of rice varieties Sahel 108, Sahel 328 and Sahel 329 cultivated and consumed in Senegal. For each rice varieties studied, 1 kg of paddy was collected as a sample, cleaned and then soaked at 80°C for 16 hours. Afterwards, phytate and mineral contents were quantified. The study found a calcium content ranged from 108.96 to 142.25 mg/100g. For iron content, 3.61, 2.10 and 2.66 mg/100g were obtained for Sahel 108, Sahel 328 and Sahel 329, respectively. These different results shown that Sahel 108 presented the highest iron and calcium contents. Concerning phosphorus and potassium contents, 80.28, 100.89 mg/100g and 112.91 and 96.53, 92.99 and 127.83 mg/100g were, respectively for Sahel 108, Sahel 328 and Sahel 329. For these two minerals, Sahel 108 presented the lowest content. The results shown that all the untreated samples had similar phytate contents varying from 151.0 mg/100g to 170.1 mg/100g. The study revealed that, in one hand the rice varieties Sahel 108, Sahel 328 and Sahel 329 also contained phytates that inhibit the bioavailability of minerals like iron and in another hand, parboiling reduced significantly phytate levels while preserving mineral elements.

Keywords Rice, Phytates, Minerals, Parboiling, Senegal River valley

1. Introduction

Rice is one of the most important cereal in the world for human consumption. According to FAO [1], world production of milled rice is estimated at 511.2 million tons in the 2019/2020 season. In Senegal, this production amounted to 1,155,337 tons for the same period [2].

In Africa, rice consumption increases due to urbanization and changes in consumer food preferences [3]. Indeed, sub-Saharan Africa alone recorded more than 32 million tons of rice consumed in 2018/2019 according to USDA [4].

In Senegal the average of annual rice consumption is estimated at 1,080,000 tons, of which 650,000 come from imports and 430,000 from national production according to Galán and Drago [5]. Rice is an important source of minerals and vitamin B for human beings. Minerals are essential nutrients for human health because they play an important role in the physiological processes of the human body [5]. To this end, thiamine is closely related to normal glucose metabolism in the brain and its deficiency can weaken human memory [6]. In addition, studies have shown that rice varieties contain iron varying between 11.25 and 14.17 mg/kg, zinc 37.5 mg/kg and calcium 19.93 mg/kg [7] [8].

Like many other grains, rice contains anti-nutritional factors that reduce the availability of its nutrients. Among other anti-nutritional factors, phytates are one of the more known. Indeed, the presence of phytates in food is associated with a reduced absorption of minerals due to their structure allowing them to form very stable complexes with mineral ions [9].

In 2009, Norhaizan and Nor [7] found phytate levels ranging from 36.40 to 76.24 mg/100g in rice samples and rice products. Tamanna and al. [10] also found higher phytate contents in rice samples ranging from 405 to 635 mg/100g.

To reduce the effect of phytates on minerals, several

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technological methods have been used. These were mainly dehulling, cold soaking and sprouting, among others. Dehulling is a method that is carried out by abrasion of the grain, causing the elimination of the bran where a very important part of the phytates is located. Cold soaking is often used in cereal processing to reduce phytates. Germination is a period in the life cycle of plants when they begin to emerge from the seed. It increases the availability of nutrients in grains by reducing phytates with activation of enzymes.

Although, all of these processes significantly reduce the phytate contents of grains generally and rice particularly, they also lead for mineral losses. Their application also remains limited because of the additional workload they impose or the particular organoleptic properties they induce. Thus, it is urgent to find an alternative process which reduces both the phytate contents and the mineral losses.

For paddy rice, Nadia et al. [11] demonstrated that parboiling is a post-harvest process that significantly reduces nutrient losses during shelling and cooking. Thus, the purpose of this study was to determine the mineral contents (Fe, Ca, P, K) and to study the effect of parboiling on the phytate contents of rice varieties Sahel 108, Sahel 328 and Sahel 329 cultivated and consumed in Senegal.

2. Material and Methods

The plant material used in this study consisted of three rice varieties Sahel 108, Sahel 328 and Sahel 329. Samples were taken in test plots from Mbagam in the Senegal River valley conducted by Centre de Recherches Agricoles de Saint Louis.

2.1. Parboiling

For each rice varieties studied, one (1) kg of paddy was collected as a sample, cleaned and then soaked at 80°C for 16 hours. The precooked rice was dried until an average water content of 14% before husking using an Engelberg machine.

2.2. Preparation of Samples for Analysis

For each variety, there was an un-parboiled (NE) and a parboiled (E) samples. These were for Sahel 108 respectively S-108 NE and S-108 E, for Sahel 328 S-328 NE and S-328 E and for Sahel 329 S-329 NE and S-329 E.

For each sample, 100g of rice was taken, ground using a mill 3100 brand of laboratory mill, packaged in polyethylene bags and kept at 4°C until use.

2.3. Determination of Phytates

The method described by Latta and Eskin [12] and Vaintraub and Lapteva [13] was used with a slight modification. Thus, sample of 1.2g was placed in a 50 ml tube, in which 40 ml solution of 2.4% HCl was added. The tubes were left at room temperature for 2 hours. Thus, each tube was vortexed for 15 seconds, every 10 minutes. After 2 hours, the tubes were centrifuged at 2800 rpm for 30 minutes. Then, 5 ml of the obtained supernatant was diluted in 45 ml dionized water before homogenizing. A 5 ml of Wade's rose was added to 15 ml aliquot of the previous solution. The reading was done at 500 nm using UV spectrophotometer.

2.4. Determination of Minerals

The mineral contents were determined according to AOAC [14] method. The method consists to measure the elements by Atomic Absorption Spectrophotometry after sample incineration and dissolution of the ash into hydrochloric acid solution. Minerals content in samples were determined using calibration curves from established range of standard solutions.

3. Results and Discussion

3.1. Minerals Content of the Three Varieties Sahel 108, Sahel 328 and Sahel 329

The mineral contents of the studied rice samples were shown in figure 1. These were calcium, iron, phosphorus and potassium.

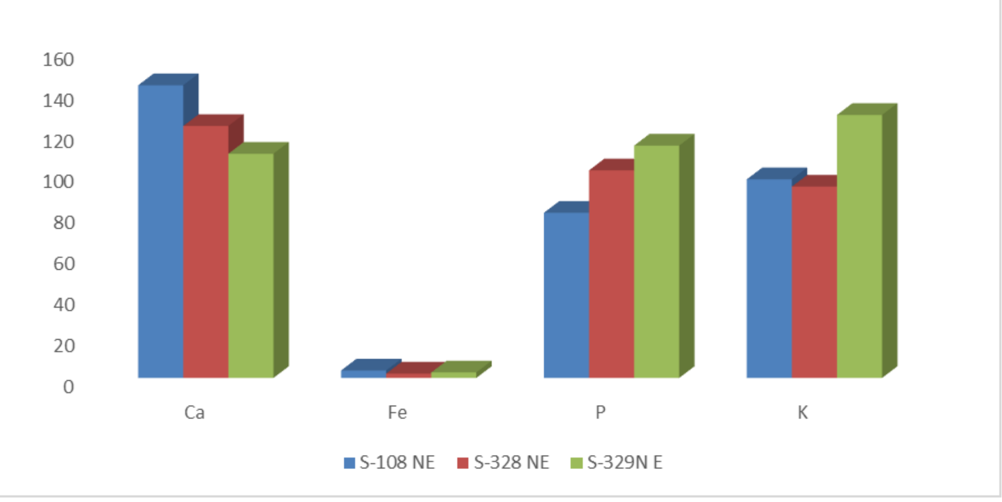

Figure 1. Variation of minerals content depending on rice variety

The study found a calcium content ranged from 108.96 to 142.25 mg/100g. In a study examining the levels of phytates, calcium, iron and zinc and their molar ratios in foods commonly eaten in China, Ma et al. [15] found lower calcium content of 2.52 ± 0.19 mg/100g and 3.77 ± 0.19 mg/100g in rice varieties from Heilongjiang and Thailand. Calcium content of 222 mg/100g were found very early in a study on the nutritional value and behavior of cereals during their processing [16].

The results of this study, compared with those of the literature, therefore showed that all the varieties used are very rich in calcium, but the Sahel 108 variety (142.25 mg/100g) won out over all the others (122.45 and 108.96 mg/100g for Sahel 328 and Sahel 329 respectively).

For iron content 3.61, 2.10 and 2.66 mg/100 g were obtained for Sahel 108, Sahel 328 and Sahel 329 respectively in this study. Liang and al. [17] obtained 2.60 mg/100g content of iron in Australian rice, similar to the iron content found in Sahel 329 variety and 0.70 mg/100g in Korean rice, very low compared to those in this study. Other studies very early revealed iron content of 2.20 mg/100g for Indian brown rice and 1.20 mg/100g for Vietnamese and Philippine rice [18], [19], [20], [21], [22]. These different results shown that Sahel 108 presented the highest iron content.

Concerning phosphorus and potassium contents, 80.28, 100.89 mg/100g and 112.91 and 96.53, 92.99 and 127.83 mg/100g were respectively for Sahel 108, Sahel 328 and Sahel 329. Lestienne et al. [23], reported phosphorus contents of 288, 285 and 333 mg/100g for wheat, millet and rice, respectively. For the same cereals, they found potassium contents of 363, 195 and 223 mg/100g respectively. Therefore, there was a major difference between obtained results. And for these two minerals, Sahel 108 presented the lowest content.

However, it is important to note difficulties of comparing mineral content of different varieties because their composition was extremely variable from one variety to another, from one harvest to another, or even from one field to another, for a same crop.

3.2. Effect of Parboiling on Phytate Contents

Table 1 shown the phytate contents of all studied rice samples.

Table 1. Phytate contents of parboiled and non-parboiled samples of Sahel 108, Sahel 328 and Sahel 329 rice varieties

Samples	Phytates Content (mg/100g)
S-108 E	91.7**a**
S-328 E	115.1**b**
S-329 E	121.6**b**
S-329 NE	151.0**c**
S-328 NE	165.4**cd**
S-108 NE	170.1**d**

Samples with different letters on a column are significantly different at 95%

The results shown that all the untreated samples had similar phytate contents varying from 151.0 mg/100g to 170.1 mg/100g. Phytate contents ranging from 55 mg/100g for Thai rice to 183 mg/100g for Heilongjiang rice were found by Ma et al. [15]. Their results are therefore comparable to those found in this study. By comparing phytate contents of the three untreated varieties, it clearly appears that the Sahel 329 variety has the highest phytate contents while Sahel 108 and Sahel 328 varieties have statistically similar contents.

When rice samples were parboiled, their phytate contents decreased by 19.03%, 30.07% and 46.01% for Sahel 329, Sahel 328 and Sahel 108 varieties, respectively. A reduction of about 31% was obtained when the rice was cooked without removing excess water.

Toma and Tabekhia [24] studied the effect of cooking on rice using both domestic water and deionized distilled water. The phytate contents in raw rice varieties Terso, M-5 and S-6 containing, respectively 191.8, 139.6 and 137.1 mg/100g after cooking in distilled demineralized water decreased by 187.9, 134.5 and 134.6 mg/100g respectively, i.e. 2.03%, 3.65% and 1.82% respectively. These phytate reductions were much smaller compared to those obtained in this study. Thus, it emerged from the present study that parboiling reduced significantly the phytate contents of rice grains.

The results also shown that the Sahel 108 variety was more sensitive to parboiling process considering to the reduction of phytate contents.

From this study, it can be concluded that if the intention is to produce parboiled rice with less phytates, Sahel 108 variety would be more appropriate compared to Sahel 328 and Sahel 329 varieties.

4. Conclusions

It emerged from this study that Sahel 108, Sahel 328 and Sahel 329 rice varieties were good food sources of calcium and iron and can be used to improve the nutritional status of populations, especially in developing countries. But it appeared that all rice varieties Sahel 108, Sahel 328 and Sahel 329 contained phytates which inhibit the bioavailability of minerals like iron. So, the study revealed that parboiling significantly reduced phytate levels while preserving mineral elements. However, a comparative study of the mineral content of these rice varieties, both parboiled and non-parboiled, will be implemented to study the effect of parboiling on mineral preservation.

Conflict of Interests

The authors declared that this manuscript has not been submitted to any journal for publication. They also declared have read and approved the requirements and all are aware of its submission to International Journal of Food Science and Nutrition Engineering.

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