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Comparative Study of the Protein Contents of Local and Imported Rice Consumed in Senegal

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Abstract

Protein is essential for the growth and maintenance of the body. They play a crucial role in different biological processes. This study focuses on comparing the protein contents of local rice grown in the Senegal River valley and rice imported from Asia. The objective is to evaluate the importance of the protein nutritional value of local rice compared to imported rice. Protein contents were determined using the Kjeldahl method. The results of the protein assays show that local rice varieties such as Sahel 108 and Sahel 134 grown in the Thilène basins had protein percentages comparable to those of imported rice. The protein percentages were 15.19% ± 0.91% for the Sahel 108 variety and 16.62% ± 0.01% for the Sahel 134 variety compared to 15.8% ± 0.01% on average for imported rice. Thus from the point of view of protein content, local rice has a nutritional value identical to that of imported rice which it can validly replace. It is important in Senegal to encourage local production, which would make it possible to reduce imports on the one hand and to make quality rice available to the local Senegalese market on the other. Sahel varieties with high protein contents deserve large-scale development to meet the country's protein needs.

Keywords

Proteins, Rice, Nutritional Value, Kjeldahl Method, River Valley, Senegal

1. Introduction

Rice is the most consumed cereal in Senegal ahead of millet and corn. However, local supply only covers 35% of consumption needs, estimated between 1.8 and

1.9 million tonnes (white rice equivalent), *i.e.* an average annual consumption of around 100 kg/per capita. To eliminate rice dependence on external markets, mainly Asian, the Senegalese state has set itself the objective of achieving self-sufficiency in rice. This objective has been a constant since the country's independence, even if the general pattern of public policies has varied depending on the period [1].

The rice policies of the 1980s were based on state interventionism which was very present and very costly given the results obtained. The 1990s saw a policy of State disengagement from the productive sector, directly linked to the structural adjustment programs imposed by major international donors on all developing countries. These measures, initially, allowed the reduction of imports. But the liberalization of imports, from the mid-1990s, led to a spectacular increase in Senegal's foreign purchases, going from an average of 400,000 t/year at the beginning of the 1990s, to over 800,000 t. at the beginning of the 2000s. Today, they would reach around 1.3 million tonnes. A tripling in less than 30 years [1].

During this period, production increased in the early 2010s, thanks to rice growing support programs included in the national strategy to combat poverty and malnutrition defined in particular in the second Poverty Reduction Strategy Paper (PRSP II) and in that of the Great Agricultural Offensive for Food and Abundance (GOANA) initiated in 2008. These programs made it possible to restore the self-sufficiency rate, which had fallen to less than 20% at the end of the 1990s, to around 35% today. But these results, although encouraging, are still far from the stated objectives of self-sufficiency. The cause is the disappointing progress of irrigated rice cultivation in the Senegal River Valley despite public investments and the strong appeal to national and international private investors [1].

In 2014, thanks to the Rice Initiative which made it possible to revive rainfed rice cultivation through the introduction of new improved varieties of rice, in particular the Nerica varieties (New Rice for Africa) specially intended for rainfed and lowland ecosystems developed point by African research (Africa Rice) with its international partners, as well as Sahel varieties resulting from national research (ISRA) with its regional and international partners. Subsidies for seed multiplication have been put in place and seed multiplication producers have organized themselves into a network, supported by public research and development structures and NGOs supported by international cooperation [1].

Senegal is a country with an extroverted consumption model. Faced with the cereal balance (around 2 million tonnes of production), the satisfaction of the rice needs of Senegalese consumers represents 38% of quotas including 30% from imported rice (600,000 tonnes) and 08% from local rice (150,000 tonnes). In other words, the needs Senegal's national rice producers are satisfied with 80% from imports and 20% from local production. Subject to Senegal's trade balance, the position of imported rice, considered a major concern, is more than reinforced because declining quotas estimated between 11% and 13% of overall imports, 13% and 15% of overall imports excluding products oil and 37% to 42%

of imports of food, beverages and tobacco products. The second cereal in the world after wheat in terms of production volume, rice occupies a preponderant place in the consumption habits of the Senegalese.

Senegal is one of the countries where rice consumption is daily and its use can very from once to twice, or even three times in certain places. This phenomenon of rice anchoring in the culinary choice of Senegalese households (mainly rural and sometimes urban) has established a dynamic of substitution of this speculation for local cereals other than the latter (millet/corn) [2].

Food self-sufficiency assumes that internal production is sufficient to meet the needs of the population. With the globalization of markets, this concept of food security introduces the implicit notion of the market (development incorporating a certain openness to the market). Availability, stability, and accessibility constitute the three pillars of food security. But this would be insufficient outside of a national policy of production, processing/marketing, and consumption since the situation of insecurity leads to food dependence hence the recourse of policies to food security strategies, either through self-centered development or by development access on opening to the market. The new agricultural policy aims to meet national needs with selective imports and a price policy independent of prices on the world market. These are subsidy policies, which are often not economically sustainable by certain states such as Senegal [3].

To support this policy and promote acceptance of local rice by the population, it is important to certify the quality of this rice and to assess the nutritional quality by illustrating the protein component. It is within this framework that our work falls, the main objective of which is to contribute to providing the Senegalese consumer with quality rice that is nutritionally and healthily suitable.

2. Material and Method

The material used for this study consists of:

- Kjedahlterm distiller (BUCHI) B 324; (Swiss flawil)
- Erlenmeyer, 250 mL;
- Buchi 435 mineralizing block (digestion); (Swiss flawil)
- Steam sensor K-415; (Swiss flawil)
- Burette (volumetry);
- Grindstone + mortar;
- Hood;
- Ohaus Voyager Pro precision balance, 210 g max.

The quality reagents for analysis consisted of:

Mixed catalyst (K_2SO_4 (100 g) + $CUSO_4$ (10 g) + Se (1 g));

- H_2SO_4 0.5N;
- NaOH 0.5N;
- H_2SO_4 pure concentrate 98%;
- Taschiro indicator (Methyl Red + Bromocresol Green).

Nine samples of local rice of the Sahel variety, at a rate of 250 g per sample, were taken from the basins of Thilène, Boudoum and Ngoméne in the Senegal River valley. Thus 4 Sahel varieties including 3 ordinary (Sahel 208, 108, 134) and one fragrant Sahel 177 were collected in the Thiléne basin; 3 varieties collected in the Boundoum basin (Sahel 177,134 and 108) and 2 varieties in the Ngoméne basin (Sahel 134 and Sahel 108), see **Figure 1** & **Figure 2**.

For imported rice, 04 samples from Japan, India, Thailand and Pakistan were collected from retail stores at a rate of 500 g per sample.

The protein contents of the different samples were determined by the Kjeldahl method [4].

The method consists of mineralizing the sample with concentrated sulfuric acid (H_2SO_4) in the presence of a mixed catalyst; the nitrogen is released by the addition of 40% sodium hydroxide, condensed by the Buchi distiller and trapped by an excess 0.5N sulfuric acid solution which is titrated back with 0.5N sodium hydroxide. The equivalent point is indicated by a green coloring.

A test portion of 0.5 g of each sample is weighed in duplicate on a precision balance. After grinding using a mortar and pestle, the mixture is introduced into the digestion tubes, with the addition of 15 ml of concentrated sulfuric acid (H_2SO_4) and a pinch of the mixed catalyst. The assembly is placed in the digestion device (Digestion Unit K-435,) associated with a steam sensor (Buchi Scrubber B-414,) containing a solution of sodium carbonate (200 g/L) colored with Bromothymol blue.

After one hour the digestion is stopped and the tubes placed under a hood until cooled. They are returned to the distiller (Buchi B-324) connected to two cylinders containing respectively 40% washing soda and the other demineralized water (H_2O). The distillate is recovered in a 250 ml Erlenmeyer flask containing approximately 20 ml of sulfuric acid and a little demineralized water in order to capture the ammoniac released. The excess sulfuric acid is titrated back with 0.5N sodium hydroxide. At the same time, a blank consisting of the reagents used with the exception of the compound to be determined was prepared and analyzed.

3. Results and Discussion

The data was collected and processed using the Excel spreadsheet. Statistical analyzes were carried out using Sigma Plot software. Mean comparisons were made using Analysis of Variance (ANOVA) tests followed by the Student t test when the differences were significant (the significance threshold was set at 5%).

The percentage of protein in the sample is obtained by multiplying the percentage of nitrogen by a factor F depending on the type of food analyzed.

The expression of the result: $R = [(V_0 - V) \times PM \times N \times F / Pe \times 1000]$

V_0 = Blank volume without sample;

V = Volume of NaOH poured for the sample at equivalence;

F = protein factor (here 5.70);

Pe = Test portion in grams;

PM = Molecular weight Nitrogen (14 g/mole);

N = Normality of the solution (0.5 N).

According to the basin of origin **Figure 1**.

Higher rice protein contents were found with the varieties taken from the Thiléne basin **Figure 1** with an average content of 15.83% ± 0.62%. The Boudoum basin presented the lowest protein percentage, 13.90% ± 1.5%. In Ngoméne, a percentage of 15.65% ± 0.15% was obtained. Statistical analyzes using Sigma Plot software showed no significant difference (p = 0.15).

The average protein contents of different rice varieties are shown in **Figure 2**.

The contents found were approximately identical from one variety to another even if the highest value was obtained with the Sahel 208 variety 15.72% ± 0.04%. The differences observed between the different varieties were not significant (P = 0.66).

Figure 3 illustrâtes the average protein contents of local and imported rice.

Among the imported rice samples analyzed, that from Japan had the highest protein content with 15.84% ± 0.06%. The protein contents of other rices were 15.79% ± 0.06%; 15.83% ± 0.72%; 15.83% ± 0.08% respectively for rice imported

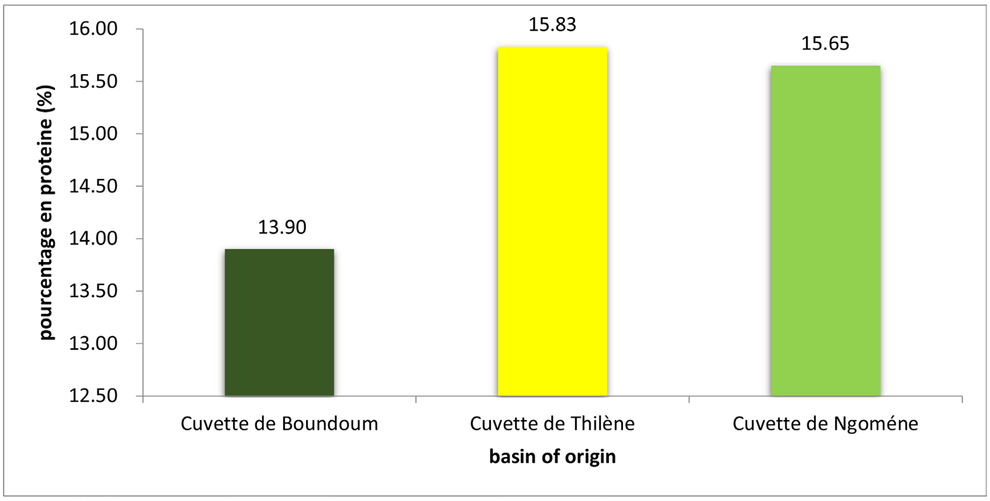

Figure 1. Average protein percentages according to the basin of origin.

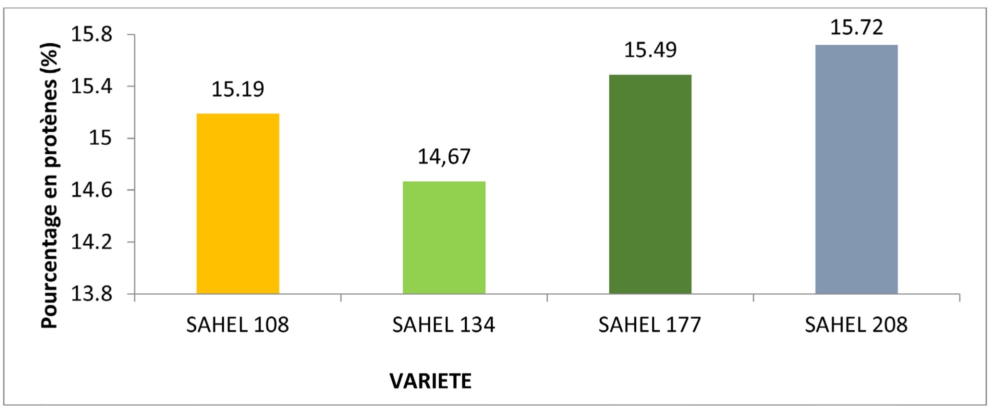

Figure 2. Average protein percentages depending on the rice variety.

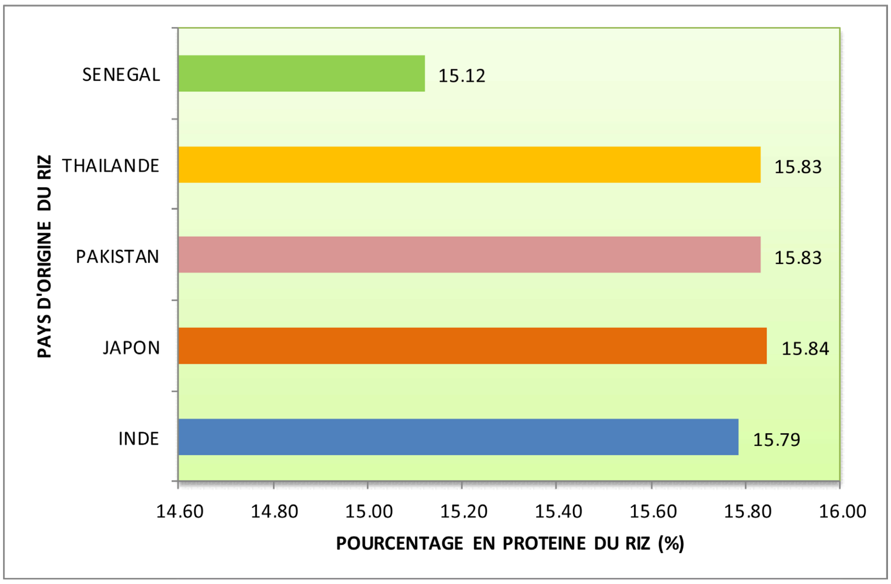

Figure 3. Comparison of protein contents of local rice & rice imported from Asia.

from India, Pakistan and Thailand. Compared to local rice, the protein contents of imported rice were essentially identical to the extent that no significant difference was observed.

Table 1 below shows the results of the assay carried out on the rice samples from the valley as well as the imported rice samples taken from the local market shops.

The samples are analyzed twice R1 + R2 then the average of the values obtained is taken, followed by the standard deviation and the coefficient of variation which is less than 5% is considered.

The highest protein contents of local rice were obtained in the Thiléne basin with an average value of 15.84% ± 0.62%. This situation can be explained on the one hand by the quality of the soil cultivated in this part of the river valley which can be rich in humus and fertilizing materials compared to the soils of the other basins. On the other hand, it can be explained by the judicious use of inputs through a more controlled application of pesticides, chemical and organic fertilizers as part of soil amendment. It should be noted that the differences between the average contents between the different basins were not significant. Depending on the variety of local rice, the protein contents were approximately equal with the Sahel 208 variety presenting the highest value 15.72% ± 0.0 4%. The Sahel 134 variety presented the lowest value which was 14.67% ± 2.01%. There were no significant differences between the contents found.

As for imported rice, that from Japan had the highest value. The other varieties of rice from Pakistan, Thailand and India had contents which were substantially identical to those found. The mean value of locally produced protein was 15.12% ± 0.01%. It should be noted that there is no significant difference.

Our study allowed us to show that local rice has satisfactory protein qualities compared to rice imported from Asia. The Senegalese market's needs for rice are

Table 1. The results of the assayed samples.

Echantillon	Poids ech1 en g	Poids ech2 en g	Vol Noah ech1	Vol Noah ech2	R1%	R2%	MOY R %	ECT	CV %
Milk contrôle F75	1.0033		17ml		4.89%				
Sahel 208 Thiléne	0.5068	0.5083	19.0ml	19.0ml	15.74	15.69	15.72	0.04	0.22
Sahel 177 Thiléne	0.5019	0.5012	19.1ml	19.1ml	15.1	15.12	15.11	0.01	0.09
Sahel 177 BD	0.5030	0.5024	19.0ml	19.0ml	15.86	15.88	15.87	0.01	0.09
Sahel 134 Thiléne	0.5044	0.5041	18.9ml	18.9ml	16.61	16.62	16.62	0.01	0.04
Milk contrôle F75	1.0026		17ml		4.89%				
Sahel 134 BD	0.5021	0.5048	19.5ml	19.5ml	11.92	11.85	11.89	0.05	0.42
Sahel 134 Ngomène	0.5035	0.5006	19.1ml	19.0ml	15.05	15.94	15.49	0.63	4.06
Sahel 108 Thiléne	0.5005	0.5053	19.0ml	19.0ml	15.94	15.79	15.87	0.11	0.67
Sahel 108 BD	0.5018	0.5031	19.3ml	19.2ml	13.52	14.27	13.90	0.53	3.82
Milk contrôle F75	1.0058		17ml		4.88%				
Sahel 108 Ngomène	0.5078	0.5023	19.0ml	19.0ml	15.71	15.88	15.80	0.12	0.76
INDE	0.5039	0.5069	19.0ml	19.0ml	15.83	15.74	15.79	0.06	0.40
PAKISTAN	0.5073	0.5009	19.0ml	19.0ml	15.73	15.93	15.81	0.72	4.05
THAILANDE	0.5058	0.5020	19.0ml	19.0ml	15.77	15.89	15.83	0.08	0.54
JAPON	0.5019	0.5048	19.0ml	19.0ml	15.89	15.8	15.84	0.06	0.40
Milk contrôle F75	1.0045 g		17ml		4.89%				

ech 1 = sample 1, ech 2 = sample, vol NaOh = volume of NaOh poured, R1 = result 1, R2 = result 2, Avg R = mean result, ECT = standard deviation, CV% < 5% = coefficient of variation, poids= weight.

estimated at around 1,000,000 tonnes; the approval of new aromatic rice varieties (Sahel 177, Sahel 328, Sahel 329) opens up interesting prospects for local rice. If these new aromatic varieties achieve a breakthrough, local rice would certainly succeed in gain market share on imported rice [5]. The quantity of rice produced in the valley over the last five years represents on average 68% of national production. Most of the national production is located in the valley. In 2011/2012 the valley produced more than 90% of local rice. The implementation of the development rehabilitation program and the subsidy of inputs were the factors explaining the considerable increase in the development and production, especially of paddy rice [6].

The Sahel 108 variety is still the most cultivated until 2015 because it ensures good yields while allowing two crops per year and it has a good milling rate. The more productive Sahel 134 and 208 varieties are increasingly cultivated. The Sahel 177 variety, the most productive of the fragrant varieties, however, only represents a few percent. These varieties with high yield potential are characterized by their short cycles (90 days for the Sahel variety and 70 for Nerica). Thanks to their introduction, producers faced, for several years, with the scarcity of rain, have seen their yields increased considerably. With the introduction of new seed varieties, yields increased from three to three. With traditional varieties, yields were 1.5 tonnes per hectare. Thanks to the project, producers obtain 5 to 6 tonnes per hectare [2].

However, studies carried out by American researchers (Pereira, Begum and Juliano, 1981; Roxas, Intengan and Juliano, 1980 in children's establishments in India and the Philippines have proven that the replacement of milled rice with medium protein content (6% - 7%) by an equal weight of milled rice with a high protein content (10%) in the children's diet improved growth, provided that the zinc element was not limiting. These results further support our values found in this study.

Furthermore, Senegal is the third largest importer of rice in Africa, behind Nigeria and Ivory Coast. Since 2014, imported quantities have been stable between 960,000 and 997,000 t per year.

One of the particularities of Senegal is that more than 98% of imports are in the 100% broken category. In 2020, this rice was mainly imported from India (32.70%), Thailand (12.20%), Pakistan (10.30%) and Brazil (13.30%). Thailand mainly supplies naturally fragrant "Jasmine" rice. Other origins mainly supply ordinary rice considering that all white rice produced and imported is consumed, per capita consumption would vary since 2014 depending on the year between 93 and 108 kg per capita per year. According to these data, the share of national production on consumption increased from 26% in 2014 to 42% in 2020 [7]. **Figures 4-6** show the evolution of rice imports in 2010 until 2020 as well as consumption per capita and per year. According to these data, the share of national production in consumption increased from 26% in 2014 to 42% in 2020.

4. Conclusions and Recommendations

Proteins are vital at all periods of life; they participate in growth, in the development of organs, they are part of the composition of enzymes (catalysts of all biological reactions). They are integrated into the synthesis of hormones and

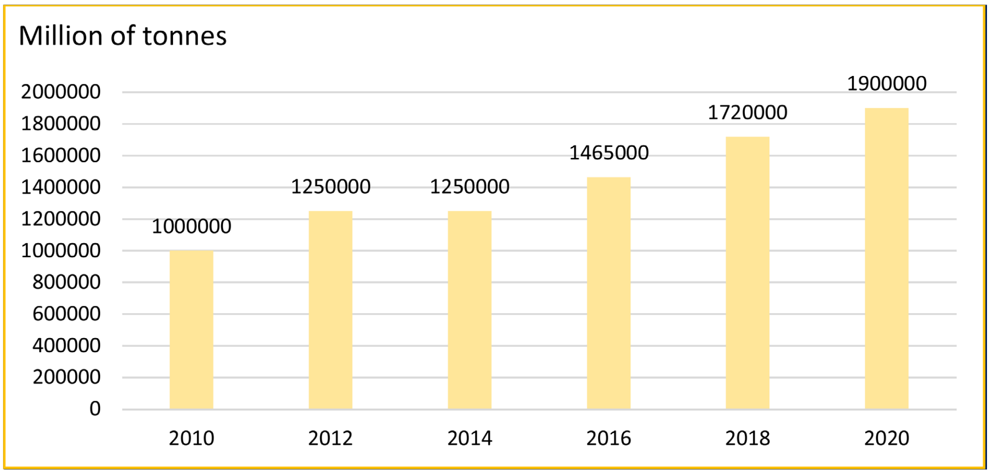

Figure 4. Show evolution of imports rice since 2010 [7].

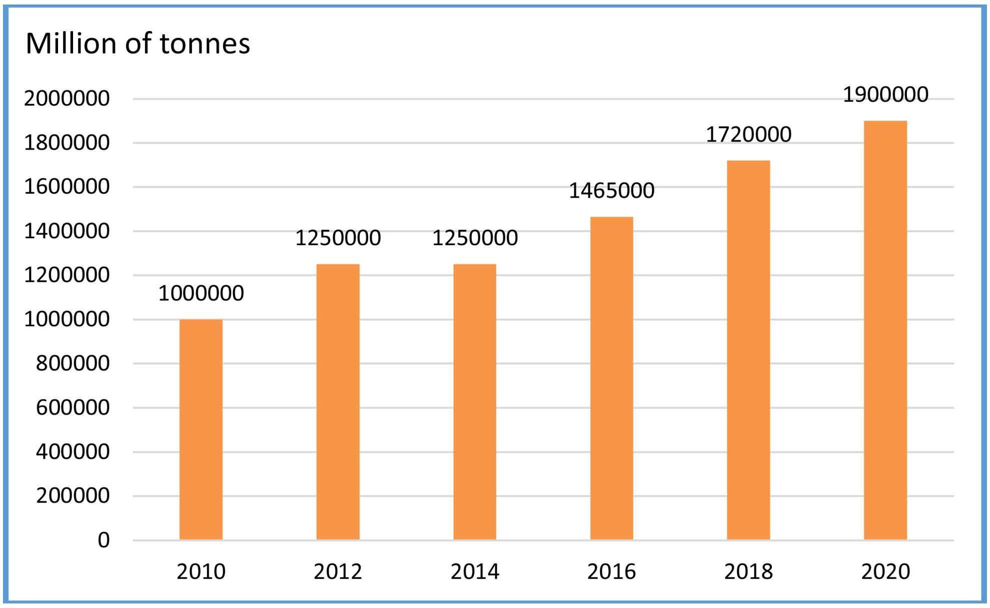

Figure 5. Show evolution of white rice consumption per year since 2010 until 2020 [7].

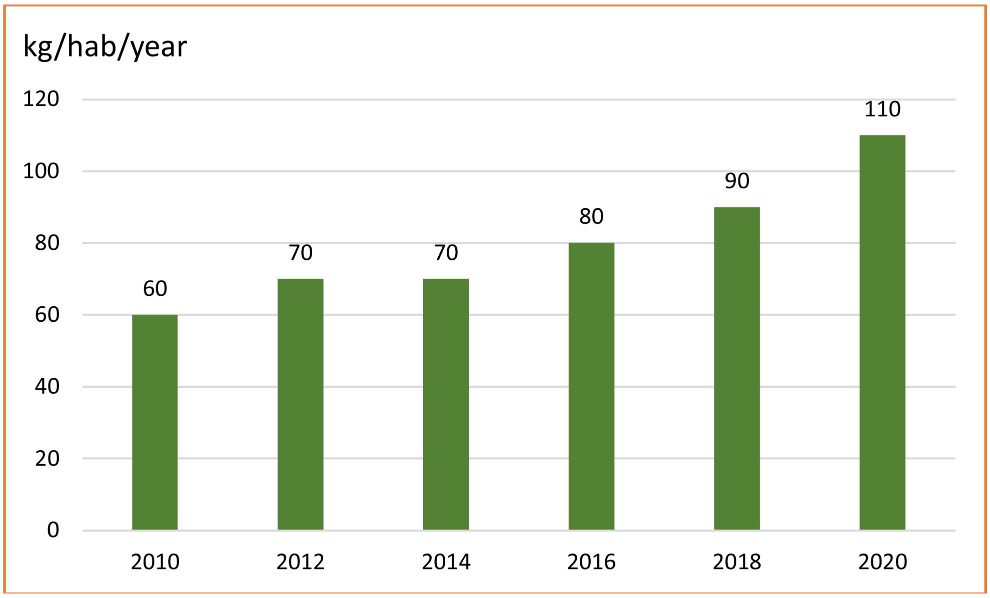

Figure 6. Show evolution of white rice consumption per capita since 2010 until 2020 [7].

promote their development, in young children, of the immune organs (thymus, lymphatic tissue, spleen, etc.) responsible for the production of antibodies. In the event of a protein deficiency, the child will be unable to fight against infections of any kind that may occur. Finally, the daily protein ration must make it possible to replace daily losses of urinary, fecal and cutaneous nitrogen [8].

The objective of the study falls within the framework of quality assurance and food safety, consisting of making sufficient and quality food available to the population.

To achieve this study objective, nine samples were analyzed to determine protein contents using the Kjeldahl method.

The results obtained showed the protein contents of local rice from the different basins were more or less identical. Furthermore, no significant difference was noted between the different varieties of local rice even if the Sahel 208 variety (15.72% ± 0.04%) had the highest content. These results found in our study show more or less identical values (15.2% of proteins, BPI-76-1) in the work of (Murata. Kitagawa and Juliano, 1978) which further supports our study carried out [9].

However, the comparison of protein contents of local and imported rice showed no statistically significant difference. This observation is important because it legitimizes the substitution of local rice for imported rice.

However, a long term solution to food problems and hunger will depend, to a large extent, on the success of agricultural and agri-food research. Significant increases in spending on research into crops and agricultural production systems will be required, with particular emphasis on food crops, namely rice cultivation. Improving the technical coefficients of agricultural production must be a priority in order to increase the availability of these resources. Increasing agricultural productivity in the context of good management of natural resources is a fundamental aspect of combating food insecurity by respecting good agricultural practices and adopting the Global GAP system which would further ensure a good increase of protein availability in rice growing in Senegal [3].

Proteins are said to be essential to humans, because they cannot be made from other nutrients (unlike carbohydrates, for example): they must therefore be provided through food. At the molecular level, proteins are made up of chains of amino acids of varying lengths. There are a total of 20 different amino acids, which can compose limitless complex arrangements between them, giving rise to the formation of an almost infinite number of possible proteins. Among these 20 amino acids: 8 are said to be essential (leucine, isoleucine, valine, lysine, methionine, threonine, tryptophan and phenylalanine, to which histidine and arginine must be added in children), and must be provided through food.

If we do not consume enough protein or the consumption is incomplete, this will lead to repercussions of such a deficit which can range from simple fatigue to brittle nails, hair loss, reduced vision, and ligaments. Weakened, osteoporosis, or even a weakened immune system.

However, the body does not know how to store proteins. We must therefore ensure that we consume sufficient protein every day, if possible at each meal, and of good organic quality [10].

In light of this study, we can formulate the following recommendations:

- Train producers in the correct application of fertilizer doses (chemical and mineral fertilizers);
- Raise awareness among the population to consume local rice because this study has demonstrated that from a nutritional point of view, local rice can validly replace imported rice.

Conflicts of Interest

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

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