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# CONTRIBUTION FOR PHYSICAL CHARACTERIZATION OF AROMATIC RICE

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## Abstract

Rice is consumed mainly as whole grain, and quality considerations are much more important than for any other food crop. Rice grain quality preference varies from country to country and among regions. Nowadays, aromatic rice varieties are playing a vital role in global rice trading, and also in Portugal. The economic value of rice depends on its cooking and processing quality, such us water uptake ratio, cooking time and texture properties.

Three types of aromatic rice were collected and analyzed for biometry characteristics, cooking time, water absorption, and texture properties. The rice grains were collected from the Portuguese trade market. Biometric characteristics of all rice grains were evaluated by S21 (LKL) and C-300 (Kett) colorimeter. The rice flour gels texture was performed by a TPA (texture profile analysis), giving information about adhesiveness, chewiness, gumminess, hardness, resilience and cohesiveness. The extrusion force was also determined according to ISO 11747:2012.

Rice samples are commercially classified as long grains B type, because they presented a length higher than 6 mm and the ratio length/ width higher than 3. The samples presented a high degree of whiteness, with a strictly relationship between the total and vitrea whiteness ($r^2 = 0.95$). The cooking time varied from 12 to 17 minutes and these properties was strongly related with water uptake (from 155.7 - 209.1 g). Generally, aromatic rice cultivars presented different textural properties. Aromatic rice samples are different for hardness, adhesiveness, gumminess, resilience, and extrusion force.

From the results obtained it was concluded that the studied aromatic rice cultivars presented different physical properties, mainly the cooking time, water uptake and texture. These differences could be a commercial advantage considering the consumer point of view, because the enterprise could provide specific aromatic rice in order to attend different consumer targets.

***Key words**: Aromatic rice, Biometric characteristics, Cooking time, Water absorption, Texture.*

## 1. Introduction

Rice (*Oryza sativa* L.) is a member of *Gramineae* family and it is one of the most important cereals cultivated worldwide, constituting the basic food for large number of human beings, sustaining two-thirds of the world population (Zhout [1]). Moreover, rice is the major food of most Asian countries and aromatic rice varieties are playing a vital role in global rice trading. Major feature of these aromatic rice varieties is aroma which is being appreciated by many people and represents a high value added trait (Dela Cruz [2]). So, rice needs attention toward improvement in its cooking qualities as well as several biochemical and morphological characteristics (Golam [3]). The demand for aroma rice is increasing day by day (Golam [4]).

Grain-type preferences vary among consumer groups. The marketing values of rice as an agricultural product depend on its physical qualities after the harvesting. The percentage of whole grain is the most important parameter for the rice processing industry (Marchezan [5]). Related with a common demand to all rice consumers, the grain or head rice must be well polished and unbroken. The geometric structure and weight of rice (*Oryza sativa* L.) kernels determine the physical characteristics and types of rice grains (shape, volume and density). Grain shape, considering the length and the ratio of kernel length to kernel width, is used by the rice industry in Portugal to classify rice into three types:

round grain (length £ 5.2 mm and length/width ratio < 2.0), medium grain (length between 5.2 and 6 mm and length/width ratio < 3), and long grain rice type-A (length > 6 mm and length/width ratio of 2 - 3) and Type-B (length > 6 mm and length/width ratio < 3) (DL nº 62 [6]).

The economic value of rice depends on its cooking and processing quality, which can be measured in terms of water uptake ratio, grain elongation during cooking, solids in cooking water, cooking time (Oko [7]) and texture properties. Furthermore, consumers' choice of rice varieties is largely based on grain and cooking qualities. Rice quality differs according to the variety and processing method used (Pomeranz [8)]. The differences in quality, which are mainly attributed to differences in colloidal structure and the extent of swelling of any variety of rice on cooking, have always been used as index of its quality (Oko [7]).

Within an individual rice particle, various processes occur during cooking. The heating, water uptake and swelling of the rice particle, all involve diffusive processes. When water is present at sufficiently high temperatures, the starch undergoes a gelatinization reaction. Many rice studies have concentrated on the soaking of rice grains at fixed temperatures (Takeuchi [9]) or the parboiling process. For temperatures below 50 $^{0}$C, the grains absorb a limited amount of water up to approximately 30% moisture content (wet basis). The resulting grains are not cooked because the starch has not undergone gelatinisation. From common experience with small samples, it is known that soaking rice grains in water at 25 $^{0}$C for about one hour is required before cooking at temperatures above 70 $^{0}$C for 20 minutes or more. As water is taken up by a rice particle, the starch granules undergo a gelatinization reaction, the term generally used to describe the swelling and hydration of the granular starch (Whistler [10]).

The objective of this work was, therefore, to evaluate three commercial aromatic rice cultivars traded and consumed in Portugal, in relation to biometry characteristics, water uptake ratio, cooking time and texture properties.

## 2. Materials and Methods

### 2.1 Samples

Three types of aromatic rice were collected from the Portuguese trade market, and they were coded with a number (the cultivar list was not revealed due to confidentiality). Flours were produced for texture measurements using a SK 100 Cross Beater Retsch hammer mill with a 1 mm sieve. After, they were sieved through a 0.5 mm sieve.

### 2.2 Biometric characteristics

Biometric characteristics of all rice grains were evaluated, using an automatic S21 (LKL, Brazil) biometric equipment and a C-300 (Kett, USA) colorimeter. An average of 700 grains for each cultivar was analysed.

The evaluated characteristics were length, width, and length/ width ratio. Other morphological characteristics were evaluated: white vitreous, total whiteness, vitreous percentage, percentage of chalky area and kett.

These determinations were done using an automatic S21 (LKL, Brazil) biometric equipment and a C-300 (Kett, USA) colorimeter. An average of 670 grains for each cultivar was analysed.

### 2.3 Cooking time

This was determined according to Oko [7] methodology with some modifications. 50 g of whole rice kernels from each sample were boiled in 500 mL distilled water. After 10 minutes 20 kernels were removed at one minute intervals until cooking. The cooking time was finish when cooked rice was pressed between two glass plates until no white core was left. This procedure was done three times for each sample.

### 2.4 Water absorption ratio

This was determined also following the procedure described by Oko [7] with some modifications. 100.0 g of whole rice kernels from each aromatic rice sample were cooked in 1000 mL distilled boiling water bath. The cooking time for each sample was in accordance of the cooking time already determined. After cooking, the samples were drained by removing the superficial water from the cooked rice. The cooked samples were then weighed accurately and the water uptake ratio was calculated as the ratio of final cooked weight to uncooked weight.

Water uptake ratio = (weight of cooked rice) / (weight of uncooked rice sample).

It was also measured the water absorption ratio after 13 minutes boiling to all the aromatic rice samples.

These procedures were done three times for each sample.

### 2.5 Texture properties

The texture profile analysis (TPA) for aromatic rice gels was made by a texturometer (TA.XT.Plus from Stable Micro Systems). The rice samples were prepared according to CEE Regulation nº 2580 [11]. The texture profile analysis was carried out by a two cycle compression test done with a flat P/75 probe. TPAs were performed in 20 samples for each state and the textural properties measured were adhesiveness, chewiness, gumminess, hardness, resilience and cohesiveness.

The extrusion force was also determined according to ISO 11747:2012 [12]. The extrusion force test was done with a rice extrusion rig (probe HDP/RE). The test mode was compression and the settings were 1.6 mm/s for test speed and 52 mm for distance.

### 2.6 Statistical analysis

All of the data represents averages of at least three different determinations. Results were analysed using the SPSS® for Windows version 21.0 software. The data was subjected to one-way analysis of variance (ANOVA) test. The separation of means or significant difference comparisons of all parameters were tested by Tukey's HSD test. Pearson correlation coefficients (r) for the relationships between properties were also calculated. The level of significance used for all the statistical tests was 95%.

## 3. Results and Discussion

The aromatic rice's studied are commercially classified as long grains B type (Figure 1), because they presented a length higher than 6 mm and the ratio length/ width higher than 3 (Portuguese DL nº 62/2000). The length and the ratio length/ width presented a correlation coefficient of 0.95.

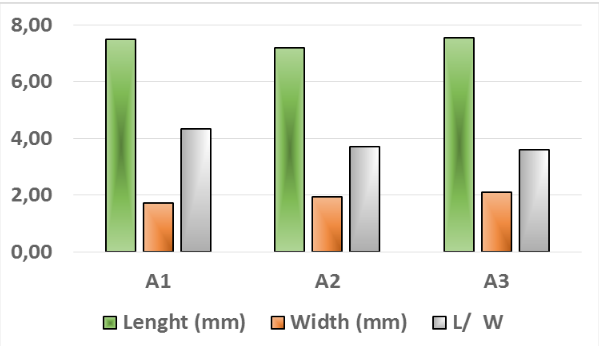


**Figure 1. Length and width of aromatic rice**

The A1 sample presented a high total whiteness and plastered area, meaning that it had not a high vitrea aspect (Figure 2). The aromatic rice's showed a great discrepancy in the plastered area results, varying from 7.9% and 20.5%, for sample A2 and A1 respectively.

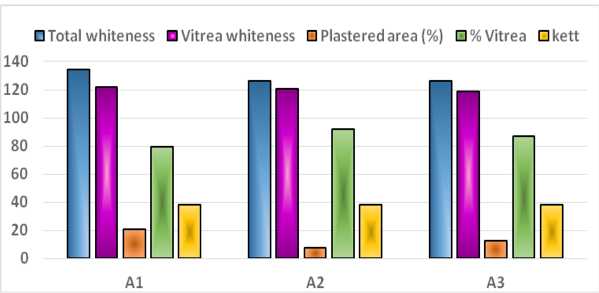


**Figure 2. Whiteness, vítrea, plastered area and kett of aromatic rice**

There was a strong negative relationship between the percentage of vitrea area and the percentage of plastered area, with $r^2$ = - 1.0. The correlation analysis also revealed a strong correlation between the total and vitrea whiteness ($r^2$ = 0.80), and it was observed a high variability in biometric measurements. The kett parameter (whiteness of all grain) was very similar for all samples with high values, and, as expected, with a strong and positive correlation to total whiteness ($r^2$ = 1.0).

The degree of milling or polishing (e.g. polishing time and polishing pressure) is an important factor that influences the quality of milled rice. Excessive polishing often leads to a high degree of breakage (Sahay [13]). In contrast, a low degree of milling can yield a low-quality head rice which will reduce its market value as a result of the incomplete removal of the aleurone layers from the kernel (Jongkaewwattana [14]). The milling operation will influence morphological characteristics as white vitreous, total whiteness, vitreous percentage chalky area, and kett (reflective index) (Gayin [15]). Chalkiness or plastered area indirectly contributes to rice breakage through easier cracking (Bhattacharya [16]). These characteristics could be changed after cooking, as it is the case of chalkiness. The chalkiness is an important physical property as it can determine whether a particular rice sample attracts a competitive price on the market, mainly because it cannot be seen after cooking (Indudhara [17]).

The rice cooking quality characteristics evaluated included optimum cooking time and water absorption ratio. In all the rice samples, the A1 variety had the lowest cooking time (Figure 3). The variation in the cooking time could be traced to its gelatinization temperature since gelatinization temperature positively determines the cooking time of rice. It has been asserted that the higher the value of gelatinization temperature, the longer time it takes to cook rice (Bhattacharya [18]). According to Bhattacharya and Snowbhagya [18], cooking time is primarily related to the surface area of the milled rice and unrelated to other grain properties. In fact our results showed a strong correlation between the cooking time and the width ($r^2$ = 0.97), and a negative correlation with the L/ W ratio ($r^2$ = -0.99).

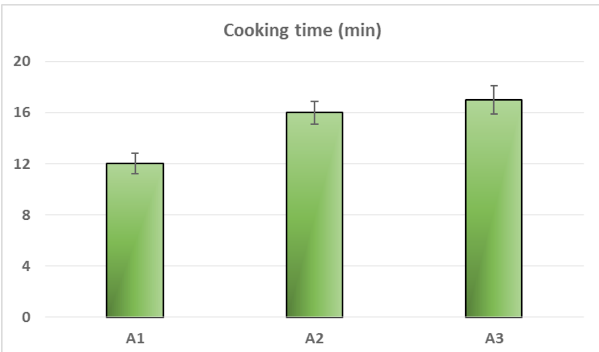


**Figure 3. Cooking time of aromatic rice**

Water uptake is considered an important economic attribute of rice as it gives an indirect measure of volume increase upon cooking (Hossaina [19]). The water absorption ratio was determined at the cooking time for each sample and to all samples after 13 minutes of cooking, in order to evaluate all the samples at the same conditions (same cooking time) and when they were completely cooked. For the same cooking time, the A1 sample absorbed the high amount of water because the cooking time was 12 minutes, thus this aromatic rice cultivar stayed 1 minute more than the cooking time, which lead to an increase of water uptake (Figure 4). In spite of this, the A1 sample at the cooking time presented the less water absorption ratio, meaning that it cooked quickly and with less water uptake. The other two samples presented at 13 minutes and at the cooking time similar behaviour.

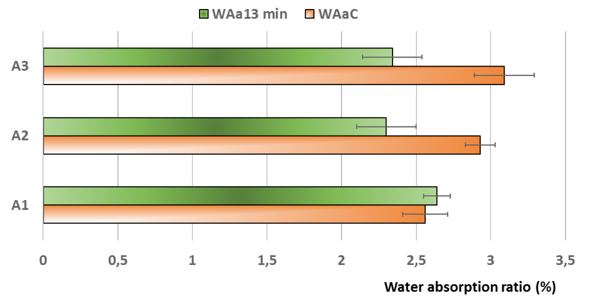


**Figure 4. Water absorption (%) after 13 minutes (WAa13) and at the cooking time (WAaC) of aromatic rice**

One of the possible explanations to those differences could be attribute to amylose content (Oko [7]). Amylose content might be responsible for high water uptake ratio, as Frei and Becker [20] had reported that rice with high amylose content tends to absorb more water upon cooking.

The textural properties were determined just for A1 and A2 samples. The TPAs of the rice gels presented significant differences in adhesiveness between samples, being the A2 aromatic rice the one which presented lower value (-5.33 Ns) (Figure 5). They also showed significant differences considering the hardness, gumminess, and resilience, with the A1 showing the high values. The chewiness, the springiness and the cohesion values were quite similar. The extrusion force showed higher values for A1 sample, meaning that the rice had high difficulty in crossing the outlet holes of the extruding equipment, probably due to the high adhesiveness, hardness and gumminess.

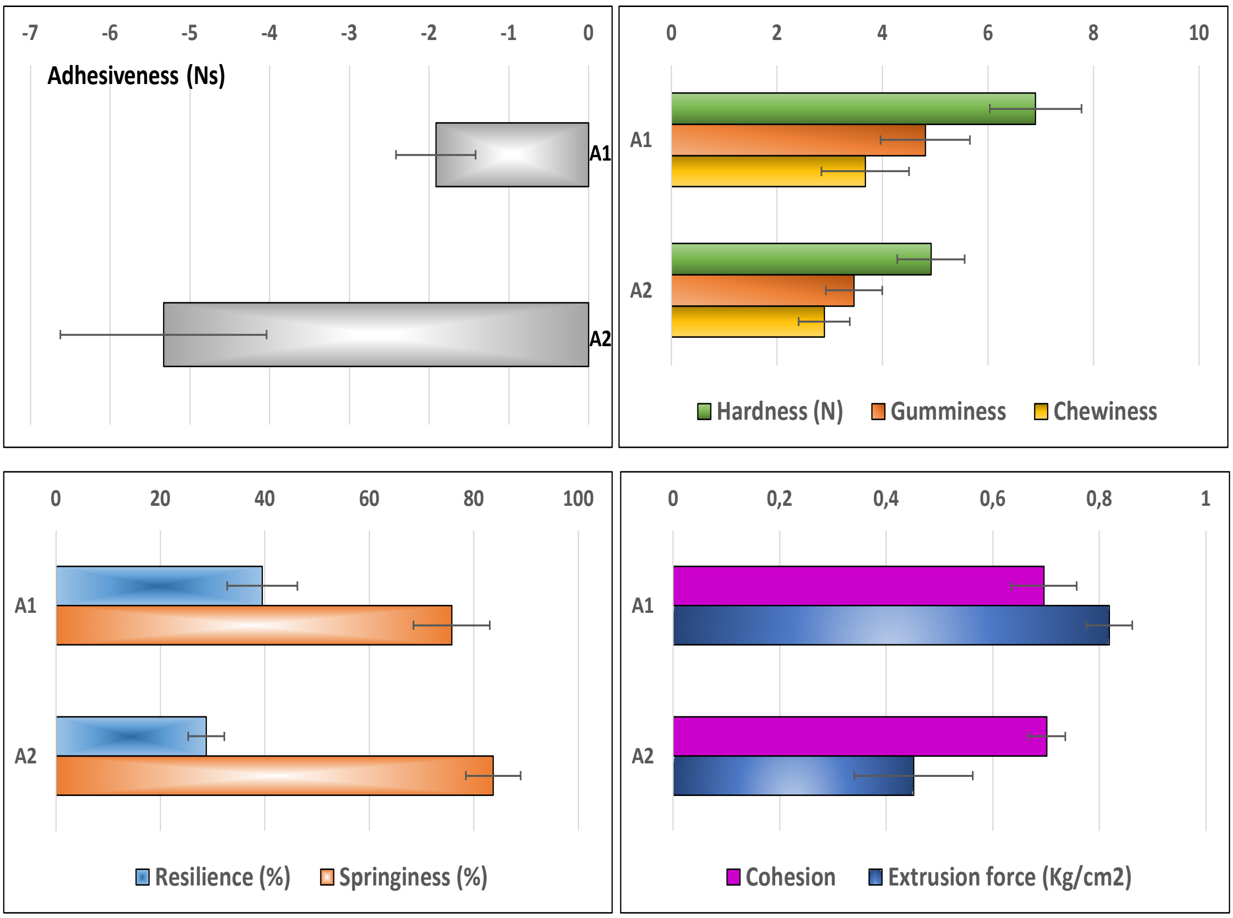


**Figure 5. Textural properties of aromatic rice**

## 4. Conclusions

- Generally it could be concluded that aromatic rice's are classified as long type-B rice, which is a good characteristic to the Portuguese trade, because long rice is market leaders due to consumers wishes and needs.

- The different aromatic rice cultivars showed to be different considering the biometric characteristics, mainly in the plastered area, and they presented high values of whiteness. One can say that the A2 sample exhibited good physical characteristics especially milling recoveries, due to the low incidence of chalkiness.

- The A2 sample cooked in less time and absorbed less water when it was cooked, and this could be related with the high values of hardness, extrusion force, and also with the lower values of adhesiveness.

## Acknowledgement

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