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PHYSICOCHEMICAL AND SENSORY CHARACTERIZATION OF FIVE PROMISING AROMATIC RICE ACCESSIONS IN BENIN

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Abstract: *Rice Research program of the National Institute of Agricultural Research of Benin (INRAB) has selected five romising aromatic rice accessions in terms of yield performance, resistance to diseases and climate change but their quality is not yet known for a better utilization, hence the objective of this present study. Thus, five promising aromatic rice accessions ARA-1, ARA-2, ARA-5, ARA-18 and ARA-23 and two released aromatic rice varieties used as check (IR 841 and BRIZ 10B) were collected in three localities (Covê, Glazoué and Malanville). Physico-chemical and nutritional characteristics of the rice samples were evaluated using standard methods. The sensory quality was evaluated by a panel of rice farmers. Results showed that the ash contents of white rice varied significantly (P<0.05) whatever accessions and highest values was obtained for accessions ARA-18 (0.70%) and ARA-23 (0.76%) and the lowest for ARA-1 (0.51%) and IR 841 (0.51%). For parboiled rice, ARA-18 (0.82%) and ARA-23 (0.85%) presented the highest ash contents while (0.55%) and ARA-5 (0 .66%) the lowest one. Protein contents varied from 7.50% to 8.76% for white rice and from 9.5% to 10.9% for parboiled rice. Parboiled type of accessions ARA-1 (3), ARA-2 (3), ARA-5 (4) and ARA-23 (2) are characterized by high gelatinization temperature (75oC -79oC) like that of parboiled type of BRIZ 10B (2). Aromatic rice accessions and checks were characterized by high level of homogeneity rate (>85%) and low (0.1 to 10%) uniformity presence of starch as well as white and parboiled rice. No significant difference (P>0.05) was observed between the swelling rates of the white and parboiled rice samples. Parboiled cooked rice (ARA-2 and ARA-5) and white cooked rice (ARA-2, ARA-18 and ARA-5) were respectively most appreciated by 70% and 65% of the panelist compared to the parboiled and white cooked check varieties, above all because of their high roma, attractive colour, non-sticky appearance and very pleasant taste.*

Keywords*: aromatic rice accessions, white rice, parboiled rice, characterization, qualities, Benin.*

1. Introduction

In the context of promotion of local rice in Benin, more than thirty rice varieties including high yielding varieties (IR 841 and NERICA L20) have been developed by research institute at various levels [1]. Despite the extensive research on common high-yielding rice varieties with successful results, consumers have an increasing preference for flavored rice [1]. To address this consumer preference, recent studies conducted in 2018 by the Rice Research Program of National Institute of Agricultural Research of Benin (INRAB), have selected 28 aromatic rice accessions

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and five of them look like promising in terms of yield, disease resistance and climate change. However, the processing and storage suitability of these aromatic rice accessions are not sufficiently elucidated. Therefore, It is necessary that physico-chemical and organoleptic tests must be conducted on those five promising aromatic rice accessions selected before their releasing. Present study was initiated in this perspective with the objective of evaluating the physicochemical, nutritional and organoleptic qualities of five promising new aromatic rice accessions in Benin.

2. Matherials and methods

Plant Material

The plant material used consisted of five promising aromatic rice accessions, namely ARA-1, ARA-2, ARA-5, ARA-18 and ARA-23 and two checks rice varieties (IR 841 and BRIZ 10B), collected in three localities (Covê, Glazoué and Malanville). Studies were carried out on the parboiled and white rice type of each rice sample. Parboiling of aromatic rice accessions is a hydrothermal treatment following the method written by authors of [2].

Physicochemical and nutritional analysis of new fragrant rice accessions

Parameters such as moisture content, alkaline digestibility, water absorption index, homogeneity rate, swelling rate, total ash content and protein content were determined on each type of rice using the methods described by authors of [3]. Moisture content was determined by drying the sample in a thermostatically controlled oven to constant weight. Five grams (5.0 g) of the sample was accurately weighed into a previously cleaned, dried and weighed glass crucible. The crucible with its content was put into the oven at 103°C for 12 h. The sample was then cooled in a desiccator and weighed. The loss in weight expressed as a percentage of the initial weight of the sample gives the moisture content of the sample.

For the determination of Ash content, 2.0 g sample was weighed into a previously dried and weighed porcelain crucible. The crucible with its content was placed in a furnace preheated to 600°C for 2 h. The sample was allowed to cool in the furnace to 250°C. The crucible and the ash were then transferred into an oven at 100°C for 30 min cooling. After this period, the crucible with its content was cooled in a desiccator. The crucible with its content was weighed. The weight of the ash was expressed as a percentage of the initial weight of the sample. Protein content was determined by microkjeldahl method and it was calculated by multiplying total nitrogen content by a factor of 5.95 to convert nitrogen content into protein content of rice. For water absorption index and swelling rate, 1 g of starch was deposited in a centrifuge tube and 25 mL of distilled water at 60°C was also added. Subsequently, the blend was centrifuged at 4500 rpm for 15 min. The supernatant was immediately discarded in previously dry beakers at 60°C and weighed. Then, the supernatant was dried at 70°C for 12 hours after weighing the time beaker to obtain the weight of soluble starch portion. The centrifuge tubes weighed to obtain the weight of the gel.

Participatory evaluation of organoleptic quality of promising aromatic rice accessions with rice farmers

After processing rice samples, sensory tests were conducted by a panel of 15 rice farmers using the appropriate quality attributes/criteria. The assessment of different rice type (paddy, parboiled and white rice, parboiled and white cooked rice) was done on the basis of the quality criteria. Paddy rice was assessed on the basis of quality attributes/parameters such

as appearance/colour, size, length, fill rate, impurity rate. While the milled forms of white and parboiled rice were evaluated using quality attributes such as: appearance, hull breakage, presence of white core, presence of black spot and overall acceptability. Finally, the cooked forms of parboiled and non-parboiled (white) rice were evaluated with respect to colour/appearance, aroma, taste, chewability, stickiness and overall acceptability.

Statistical analysis

The data were processed using Microsoft Excel 2013 spreadsheet software and SPSS V21.0. One-way analysis of variance (ANOVA) was performed for means comparison. The Student - Newman-Keuls Multiple Comparisons test were performed in order to verify weather eventual postural variations in the different mandibular positions were statistically significant

3. Results and discussion

Physico-chemical characteristics of white and parboiled aromatic rice accessions

In the white rice, it was observed that the ash content varied significantly (p<0.05) from 0.31% (check 2) to 0.76% (ARA-23). The high content was observed for accessions ARA-18 (0.70%) and ARA-23 (0.76%), followed by accessions ARA-1 (0.51%) and check 1 (0.51%) (Table 2). Accessions ARA-2 (0.57%) and ARA-5 (0.54%) showed a highest ash content than check 1 (0.51%) and check 2 (0.31%). Therefore, four aromatic rice accessions ARA-18, ARA-23, ARA-2 and ARA-5 have good nutritional quality compared to the check variety due to their higher ash content. These values are lower than those found by [4] for the cargo or whole rice who reported that the majority of the mineral elements were concentrated in the bran of the rice.

Compared to the parboiled type, the results show that the ash contents of parboiled aromatic rice accessions varied significantly (p<0.05) (Table 1). Indeed, the aromatic rice accessions ARA-2 (0.79%), ARA-18 (0.82%) and ARA-23 (0.85%) showed high ash contents compared to the check variety 1 (0.55%) and check variety 2 (0.73%), ARA-1 (0.73%) and ARA-5 (0.66%). This difference is believed to be due to the parboiling process, which causes the migration of nutrient values of rice from the husk to the endosperm. The same observations were made by several authors [2,5,6] who reported that parboiling process improves the nutritional quality of rice withing variety.

Regarding protein content, it was found that content of the white rice type varied from 7.50% (ARA-23) to 8.76% (check 2). Statistical analysis showed a significant difference (p<0.05) in protein content between three aromatic rice accessions and check varieties. The aromatic rice accessions ARA-1 (7.67%), ARA-2 (7.81%), and ARA-23 (7.50%) had lower protein contents than those obtained by check 1 (8.40%) and check 2 (8.76%) (Table 2). While accessions ARA-5 (8.10%), ARA-18 (8.36%) showed similar protein levels to check 1 (8.40%) and check 2 (8.76%). Despite the fact that three aromatic rice accessions had low protein contents compared to the check varieties, these values were higher than those obtained by [7] who found lower protein contents in aromatic rice varieties in Ghana such as Royal Feast (5.3%), Marshall (5.9%) and Jasmin (5.8%).

Similarly, for the parboiled rice samples, statistical analysis showed a significant difference (p<0.05) in protein content between three aromatic rice accessions and the check varieties. The aromatic rice accessions ARA-1 (9.67%), ARA-2 (9.81%), and ARA-23 (9.50%) had lower

protein contents than the check 1 (10.6%) and check 2 (10.76). While the rice accessions ARA-5 (10.7%), ARA-18 (10.9%) showed similar protein levels to those obtained by the two check varieties. Apart from accessions ARA-1, ARA-2 and ARA-23, the other accessions as well as the two check varieties had higher protein contents than those reported by [8].

The alkaline digestibility of the five white aromatic rice accessions and the two check varieties showed is less than four (Table 2). These results indicate the balance within the rice starch between the number of long and short amylopectin chains [9]. These results also indicate that white aromatic rice samples are characterized by a high gelatinization temperature (75 °C - 79 °C). Research has shown that this high gelatinization temperature can be explained by the presence of disulphid-linked proteins in the rice that would reduce the swelling of the rice during heat treatment [10].

In the parboiled type, the accessions ARA-1 (3), ARA-2 (3) and ARA-23 (2) were also characterized by less than 4 alkaline digestibility like that of check 2 (2). While accessions ARA-5 (4), ARA-18 (4.5) showed average digestibility like that of the check1 (5.5) (Table 1). Alkaline digestibility is a very important rice parameter that correlates directly with the gelatinization temperature of cooked rice and the amount of amylopectin contained in its starch [11]. This lower alkaline digestibility of parboiled rice accessions indicates that they have a high gelatinization temperature [12]. This high gelatinization temperature would imply the use of more fuel during the cooking process of the rice, and therefore more expense for the processors, whereas accessions with medium alkali digestibility would require less fuel.

The homogeneity rate and chalkiness (presence of starchy endosperm) were also measured on the accessions. In the white rice samples, accessions ARA-1 (96.96%), ARA-2 (93.51%), ARA-5 (96.71%), ARA-18 (95.39%) and ARA-23 (95.46%) had respectively a high homogeneity rate (>85%), as those of Check1 (97.25%) and Check 2 (95.52%) (Table 2). All the white rice samples analyzed had chalkiness score equal to 1. It means that the percentage of starchy endosperm in the rice grains varies from 0.1 to 10%.

The homogeneity parameters was important to appreciate quality because the more homogeneous a rice is, the more it is appreciated by consumers. Results obtained showed the high homogeneity rate of the five (05) aromatic rice accessions mean that they will be highly appreciated by consumers like the check varieties. The low percentage of chalkiness observed with all white rice samples is similar to those obtained by [13] during the analysis of rice varieties in Benin.

The same trends for homogeneity and chalkiness parameters are obtained for the parboiled rice samples with higher values for homogeneity rate (Table 1). These results obtained for uniformity show that the five aromatic rice accessions had good quality similar to check varieties. The low percentage of chalkiness observed for all rice samples is certainly related to the intensity of temperature during the rice production cycle from filling to grain maturity stage [14].

The analysis of the swelling rate of the aromatic white rice samples revealed that no significant difference ($p>0.05$) was observed between ARA-1 (3.35) and check 1 (3.49) samples in one hand and ARA-2 (4.08), ARA-5 (4.24), ARA-18 (4.32), ARA-23 (4.62) and check 2 (4.17) samples on the other hand. However, the swelling rate of the ARA-1 and Check 1 rice samples is lower than that of ARA-2, ARA-5, ARA-18, ARA-23 and Check 2 (Table 2). From these results, it appears

that the aromatic rice accessions ARA-2, ARA-5, ARA-18, ARA-23 and check 2 contain more amylose than the other rice samples. The same observations were made for the unparboiled rice samples. According to [4], there is a positive correlation between the swelling rate of rice and the amylose content of rice.

The results on the water absorption rate of the white rice samples showed that there is a significant difference (p<0.05) between the five aromatic rice accessions and the check varieties. The accessions ARA-2 (4.30%), ARA-5 (4.37%), ARA-18 (4.13%) and ARA-23 (3.97%) showed similar water uptake to that of check 2 (4.23%) (Table 2). While the accession ARA-1 (2.90%) showed a similar water uptake rate as check 1 (3.08%). According to [15], the more the rice grain is characterized by a hard texture, the more it will tend to absorb water. Thus, the aromatic rice accessions ARA-2, ARA-5, ARA-18 and ARA-23 would be genetically characterized by a hard texture like that of check 2.

For the parboiled rice samples, a significant difference (p<0.05) was also observed between the five parboiled aromatic rice accessions and the check varieties. Thus, the aromatic rice accessions ARA-2 (4.43%), ARA-5 (4.23%), ARA-18 (4.53%), and ARA-23 (4.17%) showed high water uptake compared to check 2 (4.27%) (Table 3). While ARA-1 (3.43%) showed a similar water uptake rate as check 1 (3.25%) (Table 1). The high water uptake of rice samples ARA-2, ARA-5, ARA-18, ARA-23 and control 2 could be explained by the fact that they are characterized by harder grains than the other rice samples [16,17]. The harder the rice grain, the more water it will tend to absorb during cooking [16].

Compared to the cooking time of white rice, there was a significant variation (p<0.05) between the cooking time of the different aromatic rice accessions. The accessions ARA-2 (17.17 min), ARA-5 (18.83 min) and ARA-23 (17.67 min) showed a high cooking time compared to check 1 (15.33 min) and check 2 (14.17min). While the rice accessions ARA-1 (14.17min) and ARA-18 (12 min) showed a lower cooking time than check 1 (15.33 min) (Table 2).

For the parboiled type, the rice accessions had an average cooking time of 15.76 min (Table 1). No significant difference (P>0.05) was observed in the cooking time of accessions ARA-2 (20 min), ARA-5 (20.7 min) and ARA-23 (23.17 min) on the one hand, and accessions ARA-1 (15.83 min), ARA-18 (15.83 min), check 1 (18.83 min) and check 2 (17.17 min) on the other hand. The small difference in cooking time between the five aromatic rice accessions and the check varieties could slightly increase the production costs for the processor.

Sensory characteristics of promising aromatic rice accessions

The sensory test showed that the accession ARA-23 is more appreciated the panelist (Figure 1) compared to the two check varieties. Panelists reported that this accession has a very good appearance, medium grain rice (length and width highly appreciated) and very clean. Check 1 (IR 841), the most popular aromatic rice variety produced in Benin, takes second place because of similar traits with ARA-23. Check 2 is the least appreciated variety because it was not well filled, that's related to a water deficit during production.

Table 1.

Physicochemical characteristics of white rice husked accessions

Accessions	Water content (%)	Water activity (Aw)	Ash content (%)	Protein (%)	Alkaline digestibility	Homogeneity rate (%)	White heart (score)	Swelling rate	Water absorption index (%)	Cooking time (min)
ARA-1	10,23±0,15^{a}	0,7659±0,00^{a}	0,51±0,17^{b}	7,67±1,66^{b}	1^{a}	96,96±1,41	1^{a}	3,35±0,23^{a}	2,90±0,24^{a}	14,17±1,72^{ab}
ARA-2	10,73±0,15^{a}	0,74±0,01^{a}	0,57±0,06^{d}	7,81±0,30^{c}	1^{a}	93,51±2,30	1^{a}	4,08±0,69^{b}	4,30±0,41^{c}	17,17±1,47^{cd}
ARA-5	8,63±0,21^{a}	0,767±0,01^{a}	0,54±0,11^{c}	8,10±0,24^{b}	1,5^{b}	96,71±3,42	1^{a}	4,24±0,58^{b}	4,37±0,41^{c}	18,83±2,99^{d}
ARA-18	10,23±0,15^{a}	0,735±0,01^{a}	0,70±0,04^{e}	8,36±1,05^{a}	1^{a}	95,39±1,87	1^{a}	4,32±0,65^{b}	4,13±0,27^{c}	12±0,63^{a}
ARA-23	10,73±0,15^{a}	0,75±0,00^{a}	0,72±0,19^{f}	7,50±0,19^{b}	1^{a}	95,46±1,48	1^{a}	4,62±0,54^{b}	3,97±1,01^{bc}	17,67±1,21^{cd}
Check 1	8,63±0,21^{a}	0,757±0,01^{a}	0,51±0,11^{b}	8,40±0,68^{a}	1^{a}	97,25±0,93	1^{a}	3,49±0,76^{a}	3,08±0,75^{ab}	15,33±1,86^{bc}
Check 2	9,4±0,56^{a}	0,756±0,01^{a}	0,31±0,42^{a}	8,76±0,55^{b}	1^{a}	95,52±1,95	1^{a}	4,17±0,85^{b}	4,23±0,84^{abc}	14,17±1,17^{ab}

Means with different letters in the same column are significantly different at the 5% level using the Student-Newman-Keuls test.

Table 2.

Physico-chemical characteristics of parboiled rice accessions

Accessions	Water content (%)	Water activity (Aw)	Ash content (%)	Protein (%)	Alkaline digestibility	Homogeneity rate (%)	White heart (score)	Swelling rate	Water absorption (%)	Cooking time (min)
ARA-1	10,13±0,01^{a}	0,749±0,00^{a}	0,73±0,14^{b}	9,67±0,7^{a}	3^{a}	93.99 ± 1,38	1^{a}	3,01±0,22^{a}	3,43±0,23^{a}	15,83±1,47^{b}
ARA-2	9,77±0,1^{b}	0,741±0,00^{b}	0,79±0,02^{d}	9,81±0,5^{a}	3^{a}	94,55 ±1,23	1^{a}	4,03±0,78^{b}	4,43±0,79^{a}	20±1,67^{a}
ARA-5	10,12±0,32^{a}	0,756±0,00^{c}	0,66±0,09^{c}	10,7±0,4^{b}	4^{b}	96,06±1,02	1^{a}	3,82±0,61^{b}	4,23±0,43^{a}	20,17±3,54^{a}
ARA-18	9,84±0,2^{c}	0,743±0,00^{d}	0,82±0,07^{e}	10,9±0,5^{b}	4,5^{b}	96,83±1,57	1^{a}	4,58±0,67^{b}	4,53±0,64^{a}	15,83±1,47^{b}
ARA-23	8,67±0,3^{d}	0,747±0,00^{e}	0,85±0,14^{f}	9,5±0,9^{a}	2^{c}	94,91±2,27	1^{a}	3,77±0,36^{a}	4,17±0,39^{a}	23,17±5,60^{a}
Check 1	9,34±0,17^{e}	0,733±0,03^{f}	0,73±0,01^{b}	10,6±0,45^{b}	5,5^{d}	93,80±3,06	1^{a}	3,13±0,97^{a}	3,25±1,66^{a}	18,33±1,86^{b}
Check 2	10,12±0,18^{a}	0,75±0,01^{g}	0,55±0,61^{a}	10,76±1,02^{b}	2^{c}	95,89±0,94	1^{a}	3,89±0,95^{b}	4,27±0,43^{a}	17,17±3,49^{b}

Means with different letters in the same column are significantly different at the 5% level using the Student-Newman-Keuls test

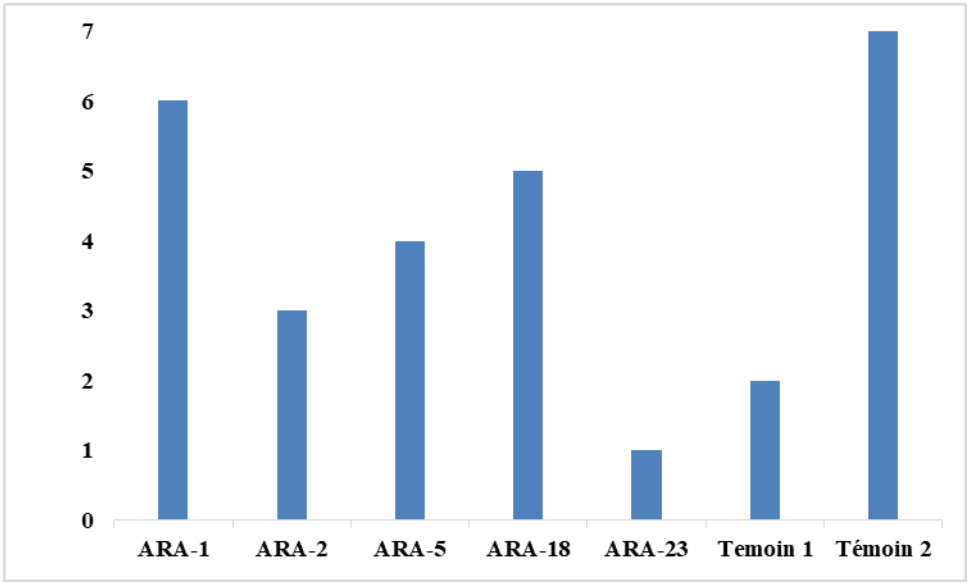

Fig. 1. Panelist preferences for paddy rice from promising aromatic rice accessions and two check (IR 841 and BRIZ 10B)

Figure 2 shows the results of appreciation of the uncooked form of white rice just after hulling. It can be seen that the aromatic rice accessions ARA-5 and ARA-2 are more preferred (70% of panelist) because these accessions have more perceptible aroma than the other accessions. Samples ARA-1, check 1 and check 2 are the least preferred.

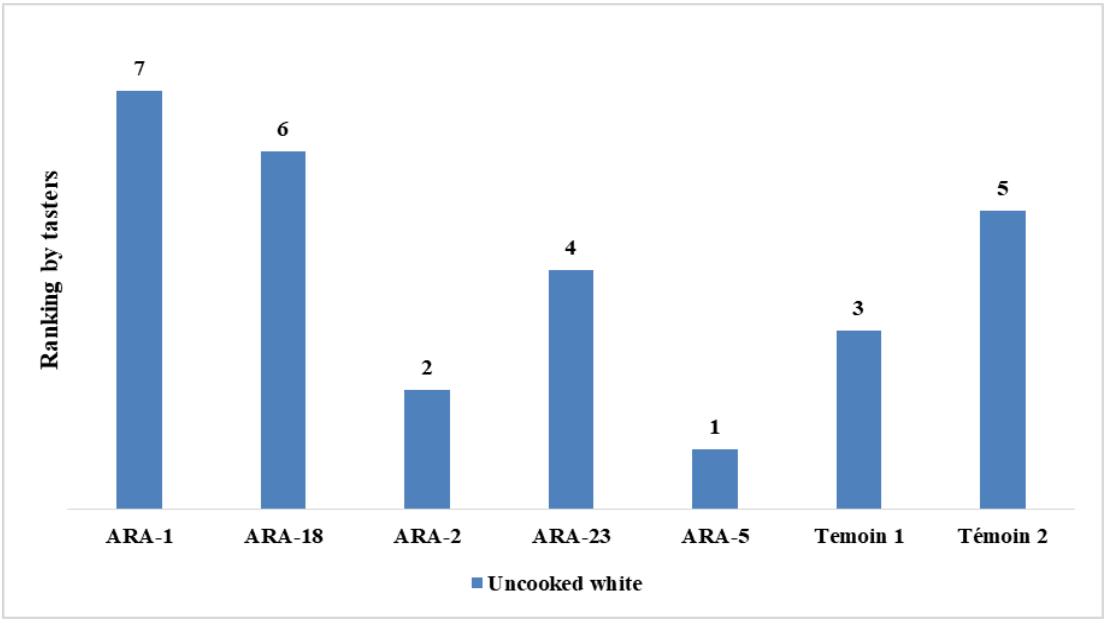

Fig. 2. Tasters' preferences for uncooked parboiled rice from new fragrant rice accessions and two check (IR 841 and BRIZ 10B)

Compared to the uncooked parboiled form (Figure 3), panelist (75%) preferred the accessions ARA-5 and ARA-23 compared to the other accessions, mainly because of the absence of black spots and the clarity of the rice. Panelist reported that these two accessions more closely look like ''AROSSO RICE'', which is the commercial name of a most appreciate parboiled rice imported and sold in Benin.

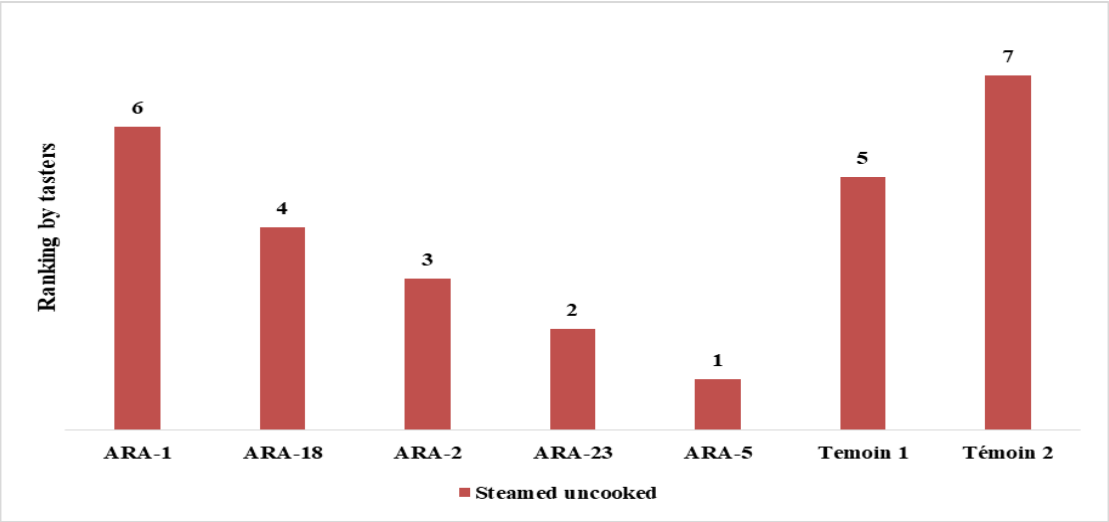

Fig. 3. Panelist's preferences for uncooked parboiled aromatic rice accessions and two check (IR 841 and BRIZ 10B)

For cooked white rice, aromatic rice accessions ARA-2, ARA-18 and ARA-5 are most preferred by panelist (65%) because of their low stickiness, strong aroma expression, good taste and easy chewiness, unlike the other accessions which are less appreciated (Figure 4).

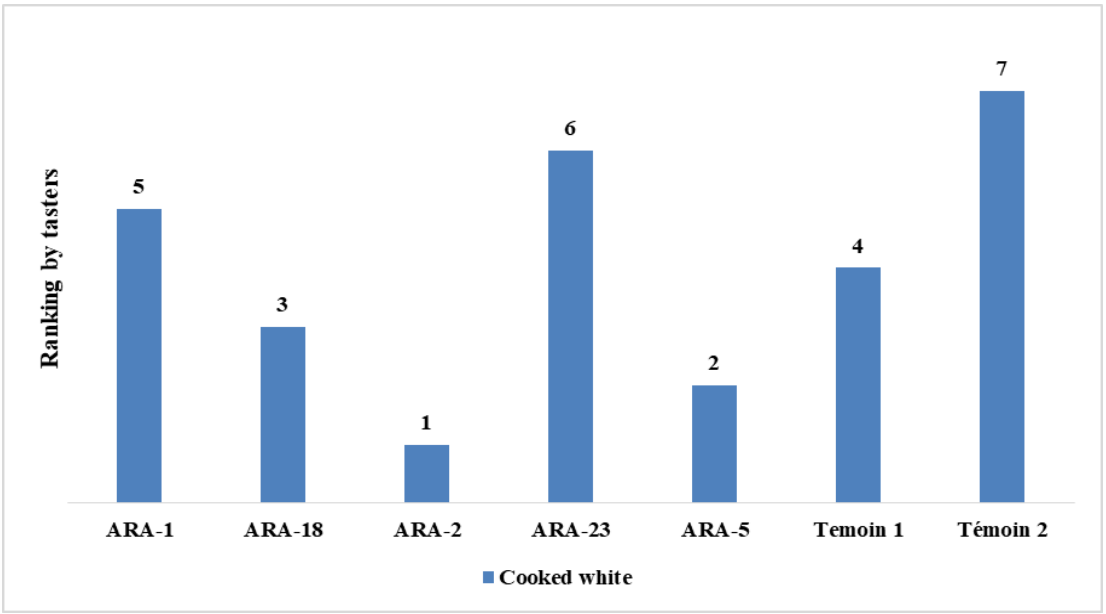

Fig. 4. Panelist's preferences for cooked white rice of aromatic rice accessions

Compared to the parboiled type, accessions ARA-5 and ARA-2 are the most appreciated by panelist (70%) because they are less sticky and have a better taste (Figure 5).

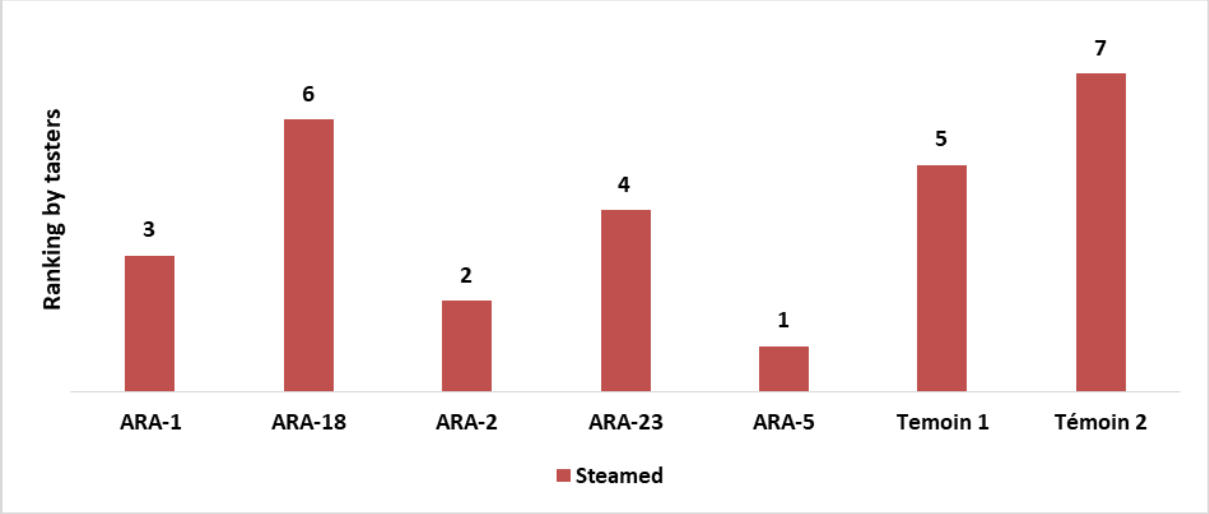

Fig. 5. Panelist's preferences for parboiled rice of aromatic rice accessions and two check (IR 841 and BRIZ 10B)

4. Conclusion

The promising rice accessions (ARA-1, ARA-2, ARA-5, ARA-18 and ARA-23) show very good physico-chemical and nutritional characteristics compared to the check used (IR841 and BRIZ-10B). All these white and parboiled type of aromatic rice accessions, as well as the check varieties, have a high degree of uniformity (>80%), low alkaline digestibility and no chalkiness. The ARA-2 and ARA-5 accessions were found to be more preferred than the checks, mainly because of the strong aroma expression, attractive color, non-sticky appearance and very pleasant taste.

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