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Cooking Characteristics of Three Parboiled Rice Varieties Locally Produced in Gogounou and Banikoara in North-Benin

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Abstract. The cooking ability of three (03) parboiled varieties (*IR 841*, *Oroukokey* and *Burkina*) was evaluated. The method used consisted of four (04) steps: (i) Experimental determination of rice cooking parameters, (ii) evaluation of the three cooking rice methods, (iii) physical quality assessment of the three cooked rice samples and (iv) validation of the best rice cooking method by the women processors. At the laboratory level, results obtained show that for 5 g of every rice variety tested, the variety *IR 841* cooked more quickly than the two other varieties with a cooking time of 24±2 min for *IR 841 and* 31.25±1.25min and 29±1min respectively for the *Oroukokey* and *Burkina* varieties. As for the swelling capacity, the *Oroukokey* varieties and *Burkina* swelled more (3.31±0.15% and 3.77±0.34% respectively) than *IR 841* variety (2.99±0.22%). Results of the three cooking methods tested with the restaurants, showed that the double cooking and the steam cooking was the most suitable method for cooking of *IR 841* whereas the direct cooking method was most preferred for the *Oroukokey* and *Burkina* varieties. In conclusion, the double cooking methods was recommended for *IR 841*while direct cooking method was recommended for the *Oroukokey* and *Burkina* varieties.

Keywords: *IR 841*, *Oroukokey, Burkina*, local, appropriate preparation.

INTRODUCTION

Parboiling is a special procedure of processing rice to improved physicochemical and nutritional properties of rice quality. Parboiled rice have higher fibre, calcium, potassium and vitamin B-6 than regular white rice. In Benin, parboiling is a common practice that is undertaken by different communities in different ways. Studies conducted under the project "Food Security Enhancing Project by the Strengthening of the value chain Competitiveness of the local dried Rice in Gogounou and Banikoara (PARCR)", revealed that three rice varieties are commonly parboiled in the communes of Gogounou and Banikoara (Hotègni *et al.,* 2019). The study further also showed that among the varieties of rice produced in the communes of *Banikoara* and *Gogounou*, the varieties *IR 841 Oroukokey* and *Burkina* were most preferred by producers and women processors for improved quality when processed. In the study variety *IR 841*was rated as the best when compared with the other two varieties regarding the processing performances. In fact, to parboil40 kg of paddy rice, the *IR 841* variety has shown low consumption of water (4.25 L) and a good quality of rice after husking with a low rate of rice grain breaking (14.94 %) and a good yield of husking (70.14 %). In spite of these

performances of the *IR 841*variety, the study also showed that this variety was not the most appreciated by the restaurant when cooked, because of its very sticky aspect (Hotègni *et al.,* 2019). Moreover, it has been reported that the women restaurant owners selling parboiled rice in these localities consider that this rice after cooking is sticky and sometime that variety loses quality when saved for consumption a following day after cooking (Houssou *et al.*, 2016a).This characteristics of *IR 841*could be due to the direct preparation that is not suitable method used by restaurants that involved boiling rice directly in water when cooking. Perhaps another method of cooking of this parboiled *IR 841* rice can give a good quality cooked rice that will be appreciated by the restaurant. However, rice is cooked in many ways. Mestres and Goyon (2017) reported that in Asia, rice is usually cooked by the water absorption method in the presence of just enough water. In Europe, cooking rice method in excess of water, cooking rice by water absorption (Creole rice), cooking rice by water absorption preceded by soaking in oil (pilaf rice) and steam cooking rice are the most popular methods of cooking rice (Son et al., 2014, Mestres and Goyon, 2017). In Benin, as some West African countries, rice is generally cooked in three different forms: the direct cooking method in water, steaming and double cooking method. Steam cooking rice method is often preceded by soaking rice for 15 to 20 minutes (Ndour et al., 2010).In these conditions the assessment of the different methods of parboiled rice cooking is then necessary in order to identify the one most suitable for the variety IR 841.Thus, the objective of this study is to determine the cooking characteristics of three parboiled rice varieties locally produced in Gogounou and Banikoara in the North-Benin.

MATERIALS AND METHODS

Framework of the Study

This study was carried out in the laboratory and then on the field with the women processors and restaurant owners. At the laboratory level, the cooking tests were carried out in the Laboratory of Food Technology Program (PTAA) of the National Institute of Agricultural Research of Benin (INRAB). On the field, the tests were conducted on the site of the NGO "Organization for Sustainable Development, the Reinforcement and the Auto-promotion of the Communities' Structures" (DEDRAS-NGO) where the processors and the restorers were gathered to select after testing, the suitable cooking method to cook parboiled rice.

Raw Material

The raw material used in this study consisted of three samples of the parboiled rice varieties (*IR 841*, *Oroukokey* and *Brukina*). These varieties were reported to be suitable for parboiling to obtain good quality raw parboiled rice in the communes of Banikoara and Gogounou (Hotègni*et al.*, 2019).

Cooking Equipment Used

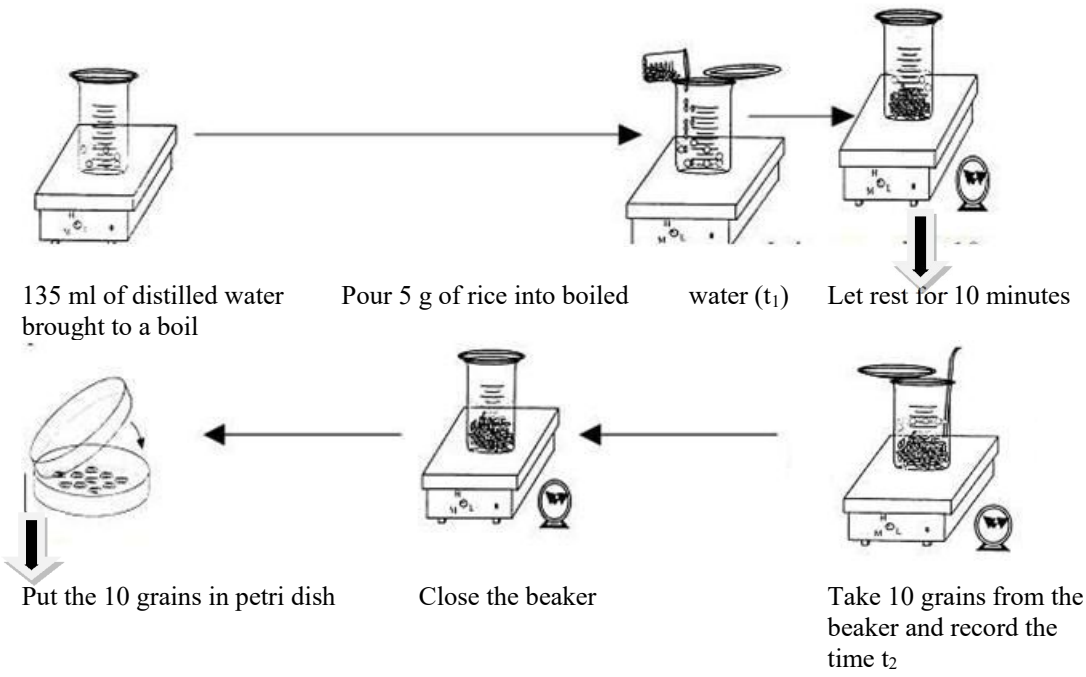
In the laboratory the same aluminium rice cooker pot is used to cook all samples of parboiled rice. The source of energy was domestic gas in order to have a same intensity of cooking fire (Figure 1).

Figure 1. Devise of cooking used in laboratory

Method

Experimental determination of the cooking parameters of the three samples of parboiled rice

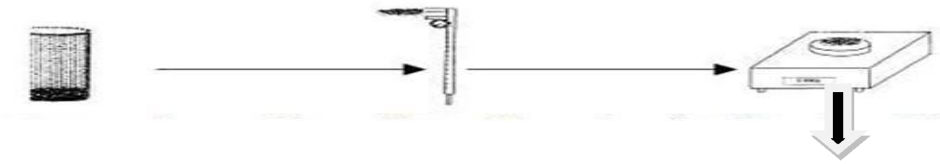
Three cooking parameters, namely: cooking time, the rate of expansion of the cook grain and the water absorption of the rice grain were determined on each rice sample in laboratory (Figure 2 and 3). To determine the cooking time, 135 ml of distilled water contained in a 400 ml beaker was boiled on a hot plate. Then, 5 g of whole husked parboiled rice was poured into the beaker. Takingt_1 the time at which the rice samples were poured into the beaker, 10 grains were removed after every 10 minutes, from the beaker and then poured into petri dish. With another petri dish with the base lower than the first one placed on the grain, a manual pressure was applied on the grains (figure 2). When 90 % of the grains are completely crushed, the time is recorded; let it be t_2. The difference of time noted $t = t_2 - t_1$ is the cooking time of the variety considered (Ganhoué, 2011). The two other parameters such as water absorption and the increase of the volume of the grains after cooking, make it possible to evaluate the swelling of the grains and have been determined according to the method described by Ganhoué (2011) and Houssou *et al.*(2016b) (Figure 3).



With the help of petri dish press the grains

When 9/10 grains are crushed, confirm the time t_2

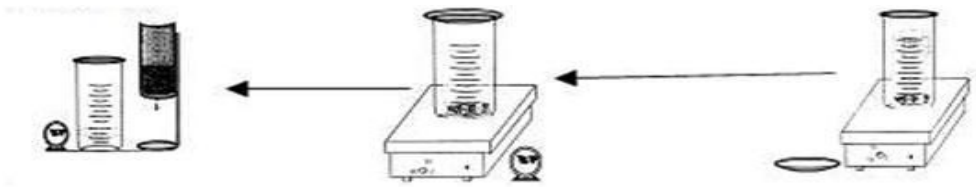
Figure 2. Process for determining the cooking time



8 g of rice pour into a metal cylinder with fine mesh

Measure the height H_1 occupied by the grains of rice

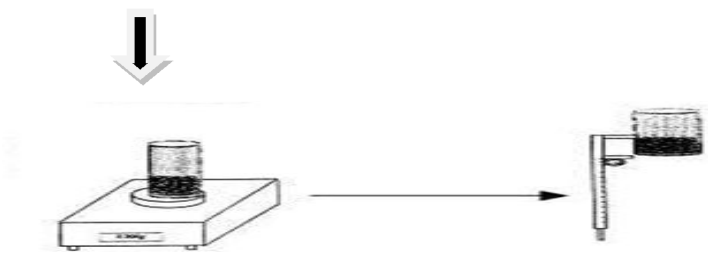
Weigh the cylinder assembly + 8 g (M_1)



Remove the cylinder and let it drain water for 2 minutes

Let grains to be cooked

Immerse the whole in a beaker containing distilled water brought to the boil



Weigh the cylinder assembly +8 g(M_2)

Finally, measure the height H_2 occupied by the grains

Figure 3. Procedure for determining the increase in volume and grain water absorption

Test of the three cooking modes of the various parboiled rice samples

On the basis of the various culinary parameters determined at the laboratory scale, each of the three rice samples were prepared by the women processors and restaurant owners according to the three cooking methods. These methods are (i) ordinary cooking/direct cooking in water without its renewal, (ii) steam cooking and

(iii) double cooking/ cooking in water with its renewal. For the ordinary cooking method a lot of 250 g of parboiled rice of each variety was taken and then washed twice with clean water. Then the washed parboiled rice was poured into a pot containing boiling water. The whole is left on fire using a gas cooker until the rice is completely cooked. Concerning the steam cooking, the same quantity of 250 g of parboiled rice previously sorted out and washed, was poured into a sieve and then covered with a muslin tissue to keep the heat. This sieve was placed on pot containing boiling water so that the water did not affect the bottom of the sieve. The whole is left on fire from a gas cooker until the rice is completely cooked. Concerning the double cooking/direct cooking in water without its renewal the same quantity of 250 g after sorting and washing was poured into boiling water to allow the rice pre-cook for 10 minutes. Then, the pre-cooked rice was removed from the boiling water and then rinse with tap water. Rinsing the rice with water after pre-cooking allows the washing of the starch dissolved in the cooking water. Finally, this pre-cooked rice is left for draining for one minute and poured into boiling water. The whole is cooked at a low heat until the rice is completely cooked.

Sensory evaluation of the physical quality of the three parboiled rice samples

The cooked rice was left to cool for 10 minutes and then served in equal portions. Twenty panellists who were typical rice eaters were invited to evaluate aroma, easiness of chewing, stickiness, taste and overall acceptability of each sample. Moreover, the samples were submitted to the same tasters 24 hours after cooking in order to assess their ability for conservation.

Validation of the cooking tests with the women processors and restaurant

At the end of the tests on station, the three varieties of tested rice were prepared in the real environment with the restaurant owners in Banikoara according to the appropriate cooking method identified during the cooking tests in laboratory. The cooked rice samples were presented for assessment to the women processors of Banikoara during the validation of the tests in the real environment/restaurant.

Statistical Analysis

The results were statistically analysed by a one-way model of variance followed by the Duncan's Multiple Range Test (DMRT) for separation of treatment means at 5 % level of probability (Steel and Torrie 1960), using the software package SPSS.

RESULTS AND DISCUSSION

Cooking parameters of the three samples of parboiled rice

Cooking time of the three varieties of the tested rice: The cooking time is an important parameter used by the consumers to appreciate or choose a variety of rice. The results obtained in this study showed that *IR 841* variety has a lower cooking time (24 ±2 min) for 250 g of rice compared to *Oroukokey* (31.25±1.25 min) and *Burkina* (29±1min) varieties for the same quantity. The duration of cooking of the *Oroukokey* and *Burkina* varieties is relatively longer compared to the dried rice AROSSO (imported rice most consumed in Benin) which is of 21 minutes for 1 kg of rice according to the works of Gankoué (2011). These relatively long cooking times increase the energy used that driven evidently an increase of preparation cost. Increase in volume and water absorption of rice grains for the three varieties tested: after the cooking of the three varieties of rice, it was observed that the grains from the *IR 841* variety has a volume increase of 2.99±0.22 % compared to Burkina and Oroukokey varieties which obtained respectively 3.77±0.34% and 3.31±0.15% (Table1).

Table 1: Rate of expansion and water absorption of the rice grains of the tested varieties

Varieties Parameters	IR 841	Oroukokey	Burkina
Rate of expansion (%)	2.99±0,22[a]	3.77±0,34[b]	3.31±0,15[b]
Rate of absorption (%)	2.69±0,03 [a]	2.45±0,06 [b]	2.44±0,01 [b]

Note: The average having the same letters on the same line are not significantly different at the point of 5%.

The statistical analysis showed a significant difference ($p<0.05$) between the *IR 841* and the two other varieties that are similar. These results show that the two varieties Oroukokey and *Burkina* expanded more than the *IR 841* rice variety. This increase in volume of these two varieties is due to the relatively high content of amylose for the two varieties compared to the *IR 841* variety. In fact, Juliano (1985) showed that there is a strong positive correlation between the content of amylose and the volume increase in rice varieties. The swelling power of the rice is a criterion for assessing the culinary quality of rice. This criterion of appreciation of cooked rice is very sought by the consumers because it results in an increase of volume of rice during cooking. Thus, on the basis of the swelling criterion of rice, the *Oroukokey* and *Burkina* varieties are better than the *IR 841* rice variety.

As for water absorption, the results showed that the *IR 841* variety absorbs more water (2. 69±0.03%) during the cooking than the two other varieties, which had an average absorption rate of 2.44±0.01% and 2.45±0.06 % respectively for the *Burkina* and *Oroukokey*. The statistical analysis showed a significant difference at the level of 5 % between the *IR 841* variety and the two other varieties. This difference is related to its relatively low content in amylose compared to the other two varieties. According to Juliano, (1993), the amylose content, the main component of rice, varies from one variety to the other.

Appreciation of rice samples prepared according to the cooking method

Ordinary cooking method

Sensory evaluation result of the cooked rice with the ordinary cooking method (Figure 4) showed that 100 % of the panellist found that the *IR 841* variety is very sticky compared to the two other varieties namely *Oroukokey* and *Burkina*.

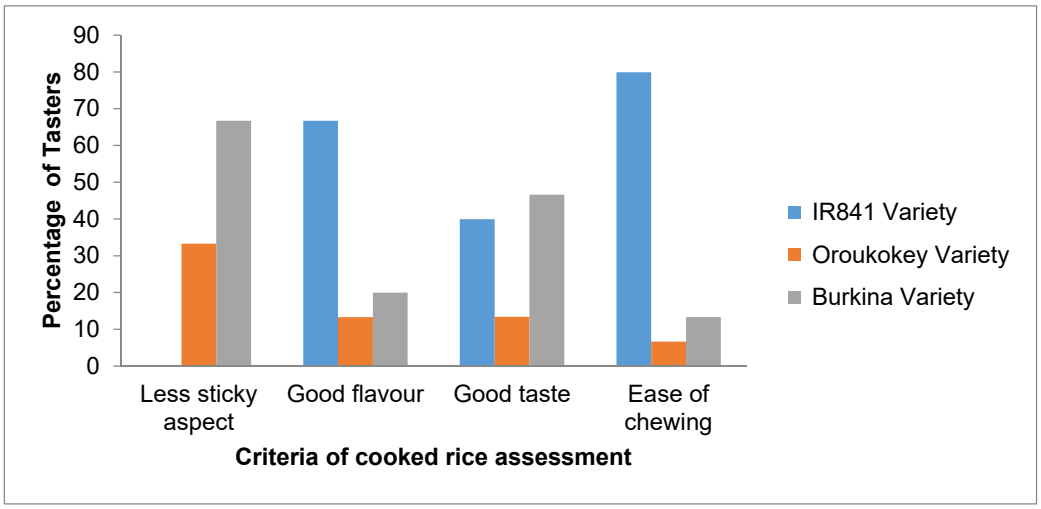


Figure 4. Appreciation by the tasters of cooked rice (ordinary cooking method)

However, some tasters (66.7 %) consider that the *Burkina* variety has a less sticky aspect compared to the *Oroukokey* variety. Concerning the flavour and the ease of chewing, the *IR 841* variety had the highest scores respectively (66.7 %) and (79.92 %). The low flavour scores (13.32%; 19.98 %) and the ease of chewing (6.66 %; 13.32 %) were obtained respectively with the *Oroukokey* and *Burkina* varieties. Finally, in relation to the taste criterion, the O*roukokey* variety was the least appreciated (13.42 %) by the tasters comparatively to the *Burkina* variety (46.62 %) and *IR 841* (39.96 %). Indeed, the results of the sensory evaluation showing the sticky aspect of *IR* 841 variety is a confirmation of the results obtained during the determination of the culinary parameters and those obtained by Hotègni *et al.* (2017). The overall evaluation of the tasters, indicated that *Burkina* variety emerges as the first (59.94% of the panellist) followed by *IR 841* (26.64% the panellist) and finally the local variety *Oroukokey* (13.32 % the panellist).

Steam Cooking Method

The results of the quality attribute assessment of prepared rice using steam cooking method showed that the *IR 841* variety is still more sticky (26.64 %) than the two other varieties *Burkina* (39.96 %) and *Oroukokey* (33.3 %), even if in relation of the ordinary cooking method, the sticky effect has been reduced (Figure 5).

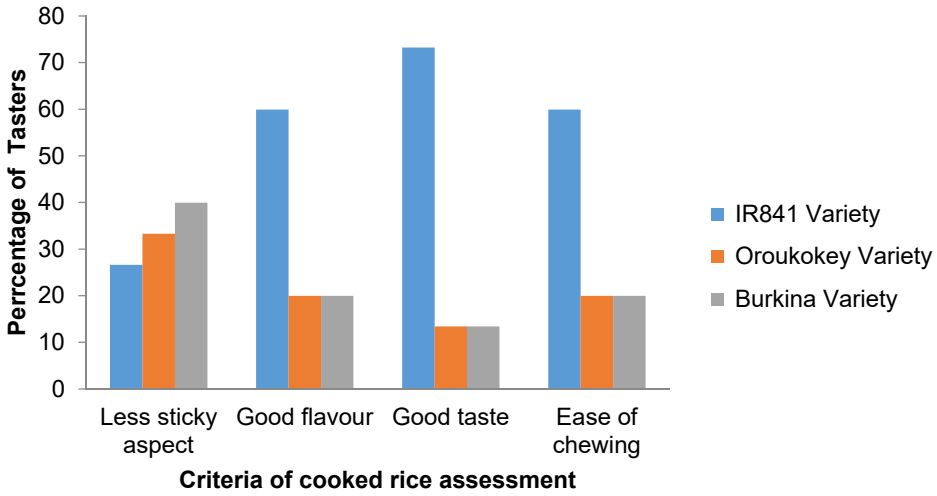


Figure 5. Appreciation by the tasters of cooked rice prepared (steam cooking method)

Thus, the sticky aspect of the cooked form of the *IR 841* is no longer pronounced when it is cooked by the steam method compared to the ordinary cooking method. As for the flavour, the *IR 841* variety is the most appreciated by the tasters (59.94 %) comparatively to the *Oroukokey* (19.98 %) and *Burkina* (19.98 %) varieties. The same tendencies were observed for the taste assessment criteria (73.26 %; 13.42 %; 13.4 %) and the ease of chewing (59.94 %; 19.98 % and 19.48 %) respectively for the *IR 841, Oroukokey and Burkina* varieties. Finally, the overall acceptability of the three samples of tested rice revealed that *IR 841*was more appreciated by the tasters (73.26 %) compared to the *Oroukokey* (13.34 %) and *Burkina* (13.34 %) when prepared using steam cooking method. We also noted that *IR 841* is even better appreciated by tasters when prepared by the steaming method compared to the ordinary cooking method.

Double cooking method

Concerning the double cooking method, the results showed that with regard to the texture of the cooked rice, the grains of the *IR 841* variety were detached from each other, which was not the case with the other cooking method specially ordinary cooking method. As a result, like the steam cooking method, the texture of the *IR 841* variety is better appreciated (33.3%) by the tasters when it is cooked by the double cooking method compared to the ordinary cooking method (Figure 6).

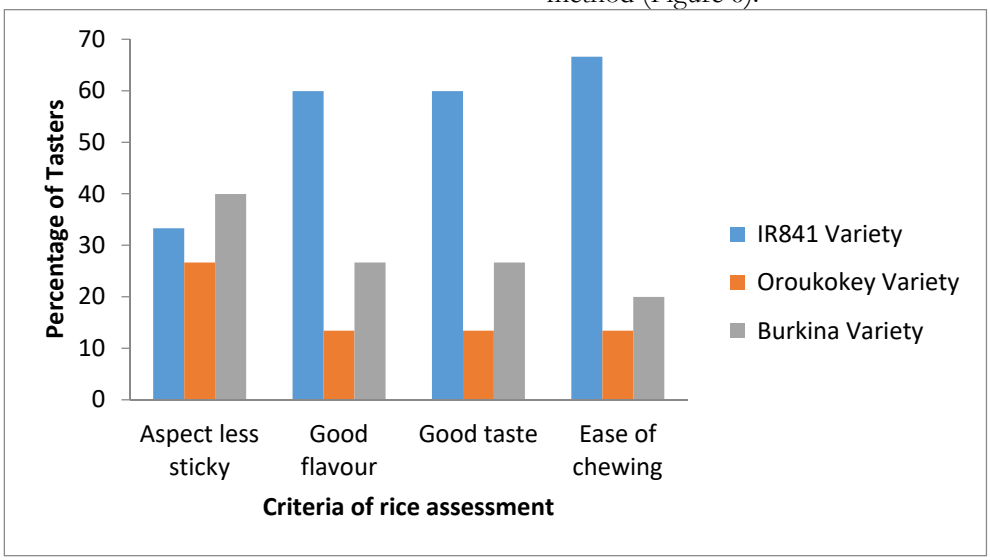


Figure 6. Appreciation by the tasters of cooked rice (double cooking method)

Indeed, the double cooking method requires a rinse of the rice with water after the first cooking (pre-cooking) of 10 minutes. This operation of rinsing the pre-cooked rice enables the reduction of the starch of rice that is dissolved in the water during the first cooking (pre-cooking). It is for this reason that during the second cooking, the rice becomes less sticky compared to the ordinary cooking method. Concerning the flavour, the *IR 841*variety was the most appreciated by the tasters (59.94 %) comparatively to the *Oroukokey* (13.42 %) and *Burkina* (26.64 %) varieties. The same trends were observed for the taste assessment criteria (59.94%, 13.42% and 26.64%) and the ease of chewing (66.6 %; 13.42 % and 19.98 %), respectively for the *IR 841, Oroukokey* and *Burkina* varieties. These results obtained for the double cooking in relation to the three criteria of appreciation such as the flavour, taste and ease of chewing, are similar to those obtained for the steaming method. Finally, the overall acceptability test of the three tested rice samples revealed that *IR 841* variety was highly appreciated by the tasters (73.26 %) compared to the *Oroukokey* (13.34 %) and *Burkina* (13.34 %) varieties.

From the analysis of figures 4, 5 and 6, it appears that the sticky texture/aspect is the criterion of appreciation which most influences the choice of the method of cooking of the varieties. Thus the double cooking and the steam cooking improve the texture of the cooked rice, in other words, reduces the sticky appearance of the rice. In the case of this study, the other criteria of appreciation (taste, flavour and ease of chewing) contribute little to the choice of the variety based on the method of cooking used because from one cooking method to another, there has not been a large variation between these three criteria. The *IR 841* variety was chosen as the best by the tasters because it recorded a low time of cooking

and good texture when prepared by the steam cooking or the double cooking. This variety which absorbs little water for cooking must be cooked according to the method of double cooking in order to avoid its sticky texture. The flavour of this variety is natural and very attractive compared to the two other varieties. Besides, the *Burkina* and *Oroukokey* varieties are similar and have many characteristics in common. Contrary to *IR 841* variety, these two varieties can be cooked using the ordinary cooking method without the grains got stick one to another. But it could take enough time to be cooked compared to the parboiled *IR 841* variety.

Appreciations of the tasters of the cooked rice samples 24 hours after the cooking

The day after the sensory evaluation, the remaining cooked rice sample were reheated and assessed by the same tasters. These tasters pointed out that whatever the cooking method used, no variety of prepared rice did ooze the next day. Moreover, *IR 841* variety of rice, cooked by the double cooking method, showed better physical characteristics according to all the tasters. Also, the women processors who participated in the various preference tests chose the *Oroukokey* and *Burkina* varieties of rice as having good characteristics in ordinary cooking.

Validation of the cooking tests in the real environment

The validation tests were carried out in Banikoara with the active participation of the women processors and the restaurants owners. According to the laboratory results, the women processors prepared the *IR 841* rice variety by using the double cooking method while the *Burkina* and *Oroukokey* rice varieties were prepared according to the ordinary cooking method. Then, the three parboiled rice samples were evaluated by all the women processors present. At the end of the assessment tests, all (100%) of the participants well appreciated the three rice samples according to their cooking method because the grains were well separated from each other, the rice grains were less sticky. They then unanimously validated the double cooking method for the *IR 841* rice variety and the ordinary cooking method for the *Oroukokey* and *Burkina* varieties. Although the double-cooking method for the IR841 rice variety is recommended, this method can drag in certain reduction of the aroma of rice in the water that is renewed during cooking.

Conclusion

It is very clear that all the three varieties of rice tested cannot be cooked in the same way and according to the same cooking methods. The output of this study indicates that it is appropriate to prepare the parboiled rice of the *IR841* variety by using the double cooking method while *Oroukokey* and *Burkina* varieties can be prepared by the ordinary cooking method.

Recommendations

As recommendations from this study, the obtained results of the suitable cooking methods of each of tested parboiled rice should be disseminated in the communes of Banikoara and Gogounou, so that the processors as well as restaurant owners will know what cooking method to be used for the cooking of particular parboiled rice variety.

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