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Evaluating rice quality produced in the Mbam rice hub in Cameroon and its association with pre- and post-harvest practices

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Abstract

Rice is a staple food in Cameroon, but its production remains relatively low to meet up local quantitative and qualitative needs. This work evaluated the current situation in regards with the physical and physiological quality of rice produced in the Mbam rice hub. Pre- and post-harvest practices were assessed by using a structured questionnaire as part of a survey during which rice samples were collected from rice actors. Physical and physiological parameters including the germination rate, moisture content, varietal purity, immature grains, fissured, whole, and broken grains percentages were assessed on rice samples in the laboratory using specific rice quality evaluation instruments and methods. A total of 80 rice samples including rice seed, paddy, and different types of milled rice were randomly collected during the survey from rice actors in four localities. The survey revealed nine rice varieties (Nerica 8, Nerica L56, Touh-Mba, Tox3145, Madam, Nerica 3, Mbankou, Sophie, and Bakala) cultivated in the hub and three major sources of rice seed, namely previously harvested paddy (69.2%), gift (23.1%), and both sources (7.7%). The analysis of physical and physiological attributes of rice seed used revealed a significant $P < 0.05$ decline in the varietal purity among farmers of Badounga (81.94%) and Nyokon (77.39%) compared to Nkolbisson (97.56%). A similar trend was observed for paddy, though with high proportions (75 to 80%) of fissured grains. Broken grains in milled rice were very high, 50.02 to 62.11%, but impurities were low in all rice samples <0.5%. A significant correlation (r = -0.93, P < 0.0001) was observed between the varietal purity of paddy and the level of broken grains. Overall, the physical quality of rice produced in the Mbam hub was poor and research innovations should be effectively used for improvement.

***Key words**:* Rice seed, Paddy, Milled rice, Quality, Rice post-harvest.

Introduction

Rice (*Oryza sativa* L.) remains one of the most valuable cereals in the world, the reason why its production in 2021 increased to 787.3 million tonnes from 694.5 million tonnes in 2010 (Food and Agricultural Organization of the United Nations [FAO], 2022). In Cameroon, with an inevitable population growth rate and progressive urbanization, rice, globally recognized as a commodity of strategic significance, is among the top staple foods consumed (Hegde & Hegde, 2013). The population of Cameroon is being faced with food insecurity more and more where more than 2.4 million people were food insecure in the late 2021, according to estimates of the Food and Agricultural Organization (FAO, 2021). However, the situation became more pronounced due to the consequences of COVID-19 outbreak, the current conflicts in the northwest, south-west, and northern regions of the country. In response to the situation, the country has projected to increase the local rice production to 750,000 tonnes by 2030 through the modernization of rice cultivation (Ministry of Agriculture and Rural Development [MINADER], 2023).

Rice is produced in all the five agro-ecological zones of Cameroon (Ngome et al., 2015) under different cropping systems, including irrigated low land, rainfed low, and upland. Conversely, local rice production is not sufficient in the country due to the poor production practices applied by farmers, contributing to high yield gaps of 5.8 t/ha reported in Africa (Tanaka et al., 2017) and very limited awareness and adoption of efficient post-harvest technologies by farmers in developing countries.

Rice seed management is an important input in rice production (LaHue et al., 2016; Wu et al., 2017). Its quality affects both production and post-harvest management, but is more often than not poor in sub-Saharan African countries including Cameroon (Toukea et al., 2021). The quality of milled rice is an important aspect for the competitiveness of rice produced in most African countries (Akoa-Etoa et al., 2016), and depends on production factors and the environment, harvesting and post-harvest operations (Mapiemfu-Lamare et al., 2017). To increase the rice production and its competitiveness in Cameroon, it is important to determine the state of art of rice cultivation and post-harvest management in the main rice production zones, including the Mbam hub. Little or no information is documented on the quality of rice produced in this hub, which is among the most important rice hubs of the country (Ndindeng, 2012). The objective of this work was to evaluate the physical and physiological quality of rice seed, paddy, and milled rice produced in the Mbam hub and associate these with pre- and post-harvest management. It was hypothesized that (i) physical and physiological quality of rice seed produced by farmers in the Mbam hub will not meet all the requirements of good seed; (ii) paddy and milled rice produced will not have good physical quality; (iii) the quality of rice produced in the Mbam hub will be associated with pre- and post-harvest management.

Material and Methods

The survey and rice samples collection

The survey was done alongside with rice samples collection, during the month of May, 2022 in the Mbam rice hub of Cameroon. This hub includes part of the West, Centre, and South regions of Cameroon and is one of the five major rice hubs of Cameroon, which include Yagoua, Lagdo, Ndop, Mbam, and Mbo (Ndindeng, 2012). The work was done in the localities currently involved in rice production and processing, namely Bandounga and Tonga city, Nyokon, and the Institute of Agricultural Research for Development (IRAD) of Nkolbisson. This last sampling area is an experimental station, which is a peri-urban community. A structured interview was done with a total of 80 rice actors (rice farmers, parboilers, millers, and marketers), randomly selected in homes, markets, and mills with the help of a local facilitator. The interview allowed the collection of information such as the production system used, the source of seed, the planting and harvesting dates, post-harvest operations (threshing, in-field staking, drying, storage, and milling), the name of rice variety sampled, packaging material used, place and duration of rice storage. During the survey, two kg of rice produced in the said localities were purchased from each rice actor for analysis. The rice samples were either seed, paddy, or different types of milled rice (white rice, parboiled milled, and red milled rice). The 80 rice samples collected from Bandounga, Nyokon, Tonga city, and Nkolbisson localities during sampling were made of rice seeds (29 samples), paddy for consumption (26 samples), and milled rice (25 samples), including white rice, parboiled rice, red rice, and brown rice.

Analysis of rice samples

Evaluation of the physiological quality of rice seed

Germination: The germination test was done in the plant pathology laboratory at the IRAD Nkolbisson. One hundred (100) grains of rice seeds were sorted randomly for each seed sample and thereafter arranged separately in Petri dishes containing adequately moist paper tissue with distilled water, under normal laboratory conditions. The germination rates were assessed seven (7) days after the incubation and the total germination percentages computed according to the International Rice Research Institute (IRRI) (2010) as follows:

$$\text{Percentage germination} = \frac{\text{Number of germinated grains}}{\text{Total number of grains}} \times 100$$

Determination of physical quality of rice samples

Moisture content: The moisture content of rice grains was determined for the seed, paddy, and milled rice sampled from the rice value chain actors in the Mbam hub. The Satake Rice Moisture meter (Satake Co. Ltd., Tokyo, Japan) was used, according to manufacturer's instructions and expressed as a percentage.

Varietal purity: The varietal purity was evaluated for the seed, paddy and milled rice sampled from the rice value chain actors using 100 g of each rice sample. The pure rice variety was separated from other varieties (foreign rice varieties) based on the size, shape, and colour of the grains. The percentage of varietal purity and the percentage of foreign varieties were calculated according to the equation 2 by the IRRI (2010).

$$\text{Percentage varietal purity} = \frac{\text{Weight of the pure variety}}{\text{Total weight of the sample}} \times 100$$

Impurities: The level of impurities was evaluated for the seed, paddy, and milled rice sampled using a sample of 100 g of each rice sample. All materials other than rice, such as dry leaves or stems, stones, weed seeds, soil, etc., were manually separated from the rice grains, weighed and the results expressed as the percentage of impurities.

$$\text{Percentage impurity} = \frac{\text{Weight of impurities}}{\text{Total weight of the sample}} \times 100$$

Immature grains: The level of immature grains was evaluated for seed and paddy using a sample of 100 g of each rice sample. The poorly filled grains or immature grains were manually separated from the normal grains and weighed and the results expressed as the percentage of poorly filled grains, using equation 4.

$$\text{Percentage immmature grains} = \frac{\text{Weight of immature grains}}{\text{Total weight of the sample}} \times 100$$

Discoloured grains: A sample of 100 g of rice was used to evaluate discoloured grains. Rice grains presenting any yellow, black, or purple colour, visualized under magnifying glass were manually selected from the normal grains and weighed. Discoloured rice grains were expressed as a percentage, using equation 5.

$$\text{Percentage discolored grains} = \frac{\text{Weight of discolored grains}}{\text{Total weight of the sample}} \times 100$$

Fissured grains: Fissures in grains were evaluated on paddy rice samples. Fifty (50) grains of paddy rice were randomly taken from each sample and hand de-husked. The fissured rice grains were then observed through the magnifying glass. The number of fissured grains was expressed as a percentage.

Whole grains and broken grains: The level of whole rice grains was evaluated using a sample of 100 g of milled rice. The whole grains were manually separated from the broken grains; weighed and the results expressed as the percentage of whole grains. The broken grains were also weighed and the results expressed as the percentage of broken grains.

All evaluations were carried out in triplicates.

Data on physical and physiological parameters was analyzed for normality and homogeneity of variance using the Kolmogorov-Smirnov test and the Levene's test, respectively. A one-way analysis of variance (ANOVA, $P < 0.05$) was conducted to determine variations in the dependent variables (physical and physiological characteristics) across the different localities. Significant means was separated using the Tukey's Honest Significant Different Test (Tukey's HSD $P < 0.05$). Also, frequencies and percentages were used to present the results from the survey carried out. All analyses were done using SPSS (Ver. 25), while Microsoft Excel was used to create graphs and tables. Where applicable, Pearson Rank Correlation ($P < 0.05$) was performed to determine the degree of association between dependent variables.

Results and Discussion

Rice production and post-harvest operations

The results obtained from the survey showed that in the Mbam rice hub 92.3% of rice was produced under rainfed lowland and 7.7% under rainfed upland production systems, where all the production depended on rain. Several rice varieties were cultivated in this hub including lowland and upland rainfed varieties, with different importance. Nerica 8 accounted for 26.9%, followed by Nerica L56 (19.2%), Touh-Mba (15.4%), Tox3145 (11.5%), Madam, and Nerica 3 (7.7% respectively), and Mbankou, Sophie, and Bakala 3.8% respectively

(Nerica means new rice for Africa). Upland rice varieties were Nerica 3 and Nerica 8, meanwhile Nerica L56, Madam, Touh-Mba, Tox 3145, Mbankou, Sophie, and Bakala were cultivated under lowland rainfed systems. Several rice varieties cultivated in a locality do not ease an effective and holistic intervention for rice production and post-harvest management. Ndindeng et al. (2021) identified strategies to increase rice productivity in sub-Saharan Africa through effective use of appropriate field production, harvest, and post-harvest practices, including the adoption of the same technology and equipment such as irrigation, parboiling, and milling machines within the locality. This cannot be possible with the cultivation of several rice varieties within a community. Rice was sown in June (61.5%) and July (38.5%) and harvested from mid-November to early January, for late harvesters. This suggests that a rigorous farm calendar was not respected by rice farmers whose planting covered the months of June and July and thus relying only on rain as a source of water during the rice production. This may be risky because with the adverse effects of climate change, farmers who plant late can run into rain shortage, in cases rain ceases earlier than initially planned. In addition, rice was harvested from mid-November to early January, for late harvesters. Leaving matured rice in the field for a long period of time leads to physical and quality losses, due to grain shattering (Paulsen, 2015), birds, and development of fissures in grains (Lan et al., 2002), respectively. There were three major sources of rice seed in the Mbam rice hub: previous harvest in one's own paddy field (69.2%), gift (23.1%), and both sources (7.7%). The farmers used part of their paddy as rice seed or got seed as gift from non-governmental organization (NGOs) or government, meaning that farmers in this hub did not have a standard seed production system and used paddy harvested for the next cropping season, which is a common practice in sub-Saharan African countries (Tiamiyu et al., 2014).

Rice farmers (100%) in the Mbam hub packaged the rice in polypropylene bags for storage, without any product for preservation and for a period, not exceeding 7 months, because paddy produced in the hub is not sufficient to cover the local needs of consumers. These farmers did not use any preservative for rice storage because rice seed is not separated from paddy during storage. They sold part of their harvest or used some for-home consumption, meanwhile the other part was used as seed. They stored rice in their living room (50%) of the house, in the kitchen (38.5%), in the room (7.7%) or in the warehouse (3.8%). The use of woven polypropylene bags for rice storage, coupled with placing these bags in the kitchen or in the living rooms placed on the floor allows the exchange of air between the grains and the atmosphere, leading to storage losses. These losses are due to insect infestation (Nwaigwe, 2019) and mould development which may produce toxins such as aflatoxins (Tang et al., 2019).

Physical and physiological characteristics of the rice seed produced in the Mbam rice hub

The results of the analysis revealed that the moisture content of rice seed from Bandounga (14.63%) and Nkolbisson (14.8%) localities were comparable but significantly higher ($P < 0.05$) than those from Nyokon locality (13.44%). This result partially agrees with that of Kaminski and Christiaensen (2014), who stated that farmers sometimes store rice at more than 14% moisture content. This is not appropriate because moisture content > 14.5% is not appropriate for good rice seed, as it can easily be conducive for the development of mould, resulting in discoloured grains (Reddy et al., 2008) which reduce seed viability (Tang et al., 2019). The rice seed from Nkolbisson had higher ($P < 0.05$) varietal purity (97.56%) than that from Bandounga (81.94%) and Nyokon (77.39%), suggesting that the rice seed from Bandounga and Nyokon localities contained other mixed rice varieties, making them not varietal or genetically pure. These results support our hypothesis that the physical and physiological quality of the rice seed produced by farmers in the Mbam hub will not meet all the required attributes of standard quality. Such seed may have different rates of germination, leading to difficult management of the field because of difference in their growth features and low quality of milled rice. These results disagree with the IRRI (2023) which defines that good rice seed should be mature with high and homogenous level of germination (more than 80%), varietal or genetically pure (absence of other mixed varieties), physically pure (without impurities such as weed seeds, seeds of other crops or species, and inert materials such as stones, dirt), healthy (free from diseases and pests) and having an appropriate moisture content (maximum of 13%). The rice seed from Bandounga locality had the highest percentage of immature grains (6.45%) compared to those from Nkolbisson (0.53%) which had the lowest percentage. Regarding empty or unfilled grains, the seed from Bandounga recorded the highest quantity (2.14%) unlike those from Nkolbisson (0.02%). Although, there was not significant difference between the germination rate of rice seed from the three localities, that from Nkolbisson was close to 98%, probably because the production was done by researchers and technicians at the IRAD. This quality is consistent with results obtained by Toukea et al. (2021). Furthermore, the level of plant and inorganic impurities was low and comparable for all the three localities (Table 1).

Tab. 1 Physical and physiological quality of seed by locality

Localities	MC (%)	GR (%)	VP (%)	FRV (%)	IG (%)	EG (%)	DG (%)	I (%)
Bandounga	14.64 ±0.88[a]	78.24±24.96[a]	81.94±9.42[b]	8.83±9.21[a]	6.45±2.78[b]	2.14±1.37[a]	2.99±2.44[a]	0.48±0.20[a]
Nyokon	13.44 ±0.70[b]	93.63±3.02[a]	77.39±6.82[b]	5.58±3.17[a]	15.37±5.78[a]	1.15±0.86[ab]	4.20±2.23[a]	0.27±0.17[a]
Nkolbisson	14.81 ±0.45[a]	97.77±1.02[a]	97.55±1.41[a]	0.03±0.06[a]	0.53±0.26[c]	0.02±.040[b]	0.00±0.00[b]	0±0.00[a]

The values followed by the same letters in the same column are not significantly different at $P < 5\%$. MC=moisture content, GR=germination rate, VP=varietal purity, FRV= foreign rice varieties, IG=immature grains, EG=empty grains, DG=discoloured grains, I=impurities.

Physical characteristics of the paddy produced in the Mbam rice hub

Paddy samples were obtained in the Bandounga and Nyokon localities. The rice paddy samples collected showed a moisture content of 14.63% for the samples from the locality of Bandounga and 13.43% for those from Nyokon (Figure 1). Although significantly different (P < 0.05), the moisture content of paddy sampled was around 14%, which is the indicated level of the paddy for milling. The varietal purity of paddy samples from Bandounga and Nyokon was comparable, but less than 83%, which is similar to that of the rice seed evaluated in this study. Rice seed made of a mixture of varieties will allow the production of paddy with the same mixture of varieties, suggesting that the varietal purity of paddy is directly related with that of rice seed. The mixture of varieties increases breakages during milling since it will be difficult to calibrate the milling machine to a fixed grain shape and size (Attaviroj et al., 2011). Thus, samples with low varietal purity are prone to breakage during milling and rice with a high proportion of broken fractions (or low proportion of whole grains) is considered low grade (Akoa-Etoa et al., 2016).

The percentage of discoloured paddy grains was not significantly different between the two localities and was 4.20% for the Nyokon paddy samples and 2.99% for those from Bandounga. The presence of discoloured grains negatively affects milling recoveries, cooking, and eating qualities (Pham Van Du et al., 2001). The average percentage of fissured grains was very high in paddy samples from both localities. The paddy from Bandounga showed 80.48±4.39% fissured grains, which was higher than that of the Nyokon samples (75.83±4.15%). The level of fissures in rice grains is related with the level of broken fractions in milled rice. Rice grains with fissures are prone to breakages during milling because fissures weaken the grain. Fissures in rice grains can be caused by moisture reabsorption of dried grains in the field (Ndindeng et al., 2014). The level of impurity of these rice samples was low, with 0.24% and 0.13%, respectively for Bandounga and Nyokon (Figure 1), suggesting that rice farmers in these localities care about the cleanliness of paddy rice by avoiding the introduction of impurities into their produce.

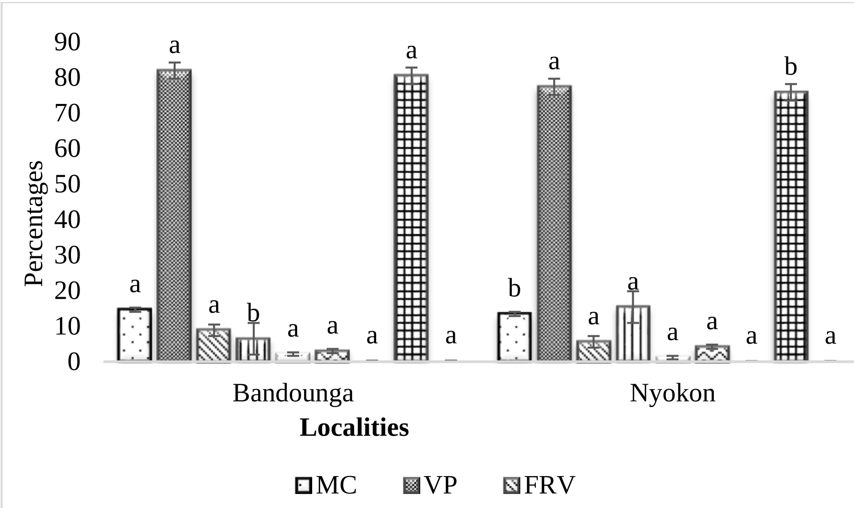

Fig. 1 Physical quality of the paddy in the Bandounga and Nyokon localities in the Mbam rice hub

Bars with same letters are not significantly different at *P* < 0.05. MC=moisture content, VP=varietal purity, FRV= foreign rice varieties, IG=immature grains, EG=empty grains, DG=discoloured grains, II=inorganic impurities, FG=fissured grains, PI=plant impurities.

Physical quality of milled rice in the Mbam rice hub

Physical quality of white rice

White rice samples were collected in the Bandounga, Nyokon, and Tonga localities. The moisture content of the white rice samples was relatively low and ranged from 11.70±0.80% for the Ton-ga samples to 12.40±0.59% for the Bandounga samples (Table 2). White rice samples showed varietal purity percentages, between 89.95±4.01 and 95.30±1.47% for white rice from Ban-dounga and Nyokon respectively. A very high level of broken grains 50.02±6.85%, 60.25±11.03%, and 62.11±2.26%, obtained for samples from Bandounga, Tonga, and Nyokon respectively corroborate with Ndindeng et al. (2014). Paddy grains, (unmilled rice grains), were present in white rice, but the level of other impurities was low (≤ 0.50%). The level of foreign rice varieties reached 10.05% for samples collected in Bandounga, (Table 2).

Tab. 2 Physical quality of white rice in three localities of the Mbam rice hub, Cameroon

Localities	MC (%)	VP (%)	FRV (%)	WG (%)	BG (%)	PG (%)	I (%)
Bandounga	12.4±0.59[a]	89.95±4.01[b]	10.05±4.01[a]	49.47±6.58[a]	50.02±6.85[b]	0.50±0.45[a]	0.50±0.46[a]
Nyokon	12.46±0.58[a]	95.30±1.47[a]	4.70±1.47[b]	37.55±2.14[b]	62.11±2.26[a]	0.20±0.13[a]	0.20±0.12[a]
Tonga	11.7±0.80[b]	92.90±6.20[ab]	7.10±6.20[ab]	39.76±10.76[b]	60.25±11.03[a]	0.33±0.50[a]	0.33±0.49[a]

The values followed by the same letters in the same column are not significantly different at $P < 0.05$. MC=moisture content, VP=varietal purity, FRV= foreign rice varieties, WG=whole grains, BG=broken grains, PG=paddy grains, I=impurities

Physical quality of red rice

One of the particularities of the Mbam rice hub is the cultivation of local rice varieties, including red rice, obtained in the Bandounga and Tonga localities. The red rice samples from these two localities were comparable for all the parameters evaluated. The level of broken grains was high, 43.49% and 37.58% respectively for samples from Bandounga and Tonga.

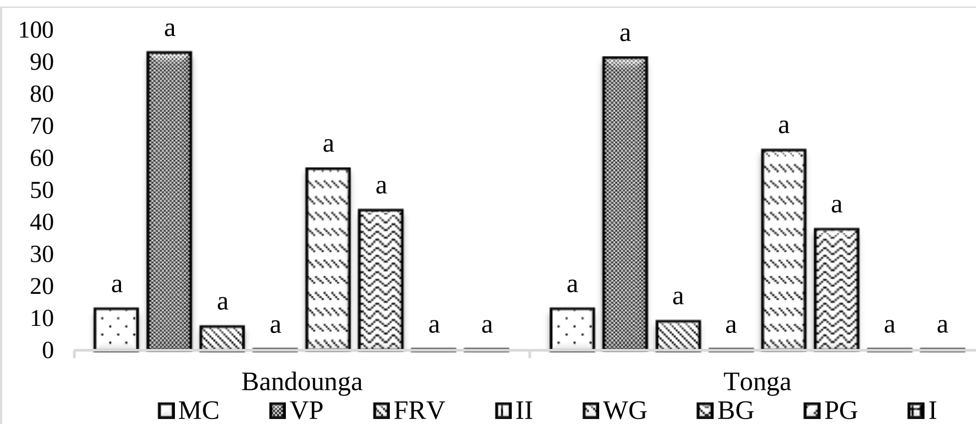

Fig. 2 Physical quality of the red rice produced in the Bandounga and Tonga localities of the Mbam rice hub

Bars with the same letters are not significantly different at $P < 0.05$. MC=moisture content, VP=varietal purity, FRV=foreign rice varieties, II=inorganic impurities, WG=whole grains, BG=broken grains, PG=paddy grains, I=impurity

A high level of broken grains observed in all the white milled rice supports our hypothesis that the paddy and milled rice produced by farmers in the Mbam hub will not have good physical quality, especially for the level of varietal purity, discoloured, fissured, and broken grains. The market value of broken milled rice is only 30–50 % of the value of head milled rice (Koutroubas et al., 2004). Broken grains in milled rice are caused by several factors, including the presence of fissures in the paddy before milling and the paddy sampled presented a high level of fissured grains. The varietal purity of the milled red rice samples from both localities was over 90% suggesting that about 10% of the sample was mixed with other rice varieties. The moisture content was less than 13% for all these red rice samples and these milled red rice samples contained negligible amounts of paddy grains (unmilled rice grains) and impurities (Figure 2). This result corroborates with that obtained on paddy rice, within this study, showing that the quality of milled rice is directly associated with that of paddy, for several attributes, including the level of impurities.

Physical quality of parboiled rice

Rice parboiling is part of the post-harvest operations in the Mbam hub and parboiled milled rice samples were obtained from the localities of Tonga and Bandounga. The rate of broken rice in the parboiled milled rice samples, although quite high (20.50±0.81% for the Bandounga samples and 16.86±0.09% for those from Tonga), was about three (3) times lower than that of red rice and non-parboiled white rice (Table 3). The low level of broken grains obtained on parboiled rice as compared to non-parboiled rice in these localities is in agreement with Ndindeng et al. (2014). Therefore, parboiling effectively improved the physical quality of milled rice (Ndindeng et al., 2014) in Bandounga and Tonga, by increasing the level of whole grains.

Tab. 3 Physical quality of the parboiled rice in Bandounga and Tonga in the Mbam rice hub, Cameroon

Localities	MC (%)	VP (%)	FRV (%)	II (%)	WG (%)	BG (%)	PG (%)	I (%)
Bandounga	12.93±0.12^{a}	82.70±1.55^{b}	17.30±1.55^{a}	0.00±0.00^{a}	79.36±0.8^{a}	20.50±0.81^{a}	0.13±0.05^{a}	0.13±0.05^{a}
Tonga ville	12.68±0.28^{a}	95.65±2.68^{a}	4.34±2.68^{b}	0.02±0.02^{a}	83.05±3.1^{a}	16.86±0.09^{a}	0.08±0.02^{a}	0.09±0.03^{a}

The values followed by the same letters in the same column are not significantly different at *P* < 5%. MC=moisture content, VP=varietal purity, FRV= foreign rice varieties, II=inorganic impurities, WG=whole grains, BG=broken grains, PG=paddy grains, I=impurities

Correlations between varietal purity and broken rice grains

There was a very strong correlation ($r = -0.93$, $P < 0.001$) between varietal the purity of paddy and the level of broken grains (Table 4). Therefore, the lower the paddy purity was, the higher the level of broken rice grains after milling.

Tab. 4 Correlation between varietal purity and broken rice grains

		Broken grains	Varietal purity of paddy
Broken grains	Pearson Correlation	1	-0.930***
	Sig. (2-tailed)		0.000
	N	12	12
Varietal purity of paddy	Pearson Correlation	-0.930**	1
	Sig. (2-tailed)	0.000	
	N	12	26

*** Correlation is significant at the 0.001 level (2-tailed).

Conclusion

The evidence on the state of physical and physiological quality of the rice produced in the Mbam hubs was provided in this study. This was achieved through a survey and evaluation of rice seed, paddy, and different types of milled rice. Paddy rice used as seed by farmers in the localities of Mbam hub did not have the attributes of good rice seed because it had a low germination rate and a high percentage of immature grains. Paddy rice presented very high percentage of fissures grains. Additionally, this study showed a very strong correlation between the varietal purity of paddy and the level of broken grains in milled rice. All the different types of milled rice were produced in the Mbam hub, including white rice, parboiled rice, red rice, and bran rice, although with poor physical quality mainly due to their high level of broken grains. The quality of rice seed in terms of varietal purity directly affects that of the paddy and the percentage of broken grains in the milled rice. Overall, the physical quality of rice produced by farmers in the Mbam hub is poor and should be improved through proper production and post-harvest management.

References

Akoa-Etoa, J. M., Ndindeng, S. A., Owusu, E. S., Woin, N., Bindzi, B., & Demont, M. (2016). Consumer valuation of an improved rice parboiling technology: Experimental evidence from Cameroon. *African Journal of Agricultural and Resource Economics*, 11(1), 8-21. https://doi.org/10.22004/AG.ECON.233845

Attaviroj, N., Kasemsumran, S., & Noomhorm, A. (2011). Rapid variety identification of pure rough rice by Fourier-transform near-infrared spectroscopy. *Cereal Chemistry Journal*, 88, 490–496. https://doi.org/10.1094/CCHEM-03-11-0025

Food and Agricultural Organization of the United Nations. (2022). *FAOSTAT Database*. https://www.fao.org/worldfoodsituation/csdb

Food and Agricultural Organization of the United Nations. (2021). *GIEWS - Global Information and Early Warning System*. https://www.fao.org/giews/countrybrief/country.jsp?code=CMR&lang=en

Hegde, S., & Hegde, V. (2013). Assessment of Global Rice Production and Export Opportunity for Economic Development in Ethiopia. *International Journal of Science and Research*, 2(6), 2319-7064. https://www.ijsr.net/archive/v2i6/IJSRON20131131.pdf

International Rice Research Institute. (2023). *Rice knowledge bank*. www.knowledgebank.irri.org/step-by-step-production/pre-planting/seed-quality.

International Rice Research Institute. (2010). *Rice knowledge bank*. www.knowledgebank.irri.org/measuring-seed-germination-fact-sheet

Kaminski, J., & Christiaensen, L. (2014). *Post-harvest loss in sub-Saharan Africa – What do farmers say?* The World Bank. https://documents1.worldbank.org/curated/es/782981468008454485/pdf/Post-harvest-loss-in-Sub-Saharan-Africa-what-do-farmers-say.pdf

Koutroubas, S. D., Mazzini, F., Pons, B., & Ntanos, D. A. (2004). Grain quality variation and relationships with morpho-physiological traits in rice (*Oryza sativa* L.) genetic resources in Europe. *Field Crops Research*, 86, 115-130. https://doi.org/10.1016/S0378-4290(03)00117-5

LaHue, G. T., Chaney, R. L., Adviento-Borbe, M. A., & Linquist, B. A. (2016). Alternate wetting and drying in high yielding direct-seeded rice systems accomplishes multiple environmental and agronomic objectives. *Agriculture, Ecosystems & Environment*, 229, 30–39. https://doi.org/10.1016/j.agee.2016.05.020

Lan, Y., Fang, Q., Kocher, M. F., & Hanna, M. A. (2002). Detection of fissures in rice grains using imaging enhancement. *International Journal of Food Properties*, 5(1), 205-215. https://doi.org/10.1081/JFP-120015602

Mapiemfu-Lamare, D., Ndindeng, S. A, Ambang, Z., Tang, E. N., Ngome, F., Johnson, J. M., Tanaka, A., & Saito, K. (2017). Physical rice quality as affected by biophysical factors and pre-harvest practices. *International Journal of Plant Production*, 11(4), 561-576. https://doi.org/10.22069ijpp.2017.3718

Ministry of Agriculture and Rural Development. (2023). *Stratégie de développement de la riziculture II.*

Ndindeng, S.A. (2012). Report on the Selection of Rice Development Hubs for Cameroon. *IRAD, Yaoundé*, 1-18.Ndindeng, S. A., Mapiemfu-Lamare, D., Fantong, W., Nchinda, V. P., Ambang, Z., & Manful, J. T. (2014). Postharvest Adaptation Strategies to the Effects of Temperature Variations and Farmer-Miller Practices on the Physical Quality of Rice in Cameroon. *American Journal of Climate Change*, 3, 178-192. https://doi.org/10.4236/ajcc.2014.32017

Ndindeng, S. A., Candia, A., Mapiemfu-Lamare, D., Rakotomalala, V., Danbaba, N., Kulwa, K., Houssou, P., Mohammed, S., Jarju, O. M., Coulibaly, S. S., Baidoo, E. A., Moreira, J., & Futakuchi, K. (2021). Valuation of Rice Postharvest Losses in Sub-Saharan Africa and Its Mitigation Strategies. *Rice Science*, 28(3), 211-216. https://doi.org/10.1016/j.rsci.2021.04.001

Ngome, F. A, Mapiemfu-Lamare, D., Tata, P. I., & Suh, C. (2015). Assessing Biotic and Abiotic Constraints to Upland Rice Cultivation in Cameroon. *Journal of Agriculture and Ecology Research International*, 3(1), 33-40. https://doi.org/10.9734/JAERI/2015/15260

Nwaigwe, K. N. (2019). An Overview of Cereal Grain Storage Techniques and Prospects in Africa. *International Journal of Bioengineering & Biotechnology*, 4(2), 19-25.

Paulsen, M. R. (2015). Harvesting: Effects of Crop Maturity and Moisture on Losses. [Paper presentation]. The First International Congress on Postharvest Loss Prevention, Oct 4-7, 2015, Rome, Italy

Pham V. D., Le Cam L., Nguyen, D. C., Huynh, V. N., & Nguyen, D. T. (2001). Survey on seed borne fungi and its effects on grain quality of common rice cultivars in the Mekong Delta. *Omonrice*, 9, 107-113. https://www.clrri.org/ver2/uploads/noidung/9-16.pdf

Reddy, N. R. K., Reddy, S. C., Abbas, K. H., Abel, A. C., & Muralidharan, K. (2008). Mycotoxigenic fungi, mycotoxins, and management of rice grains. *Toxin Reviews*, 27(3-4), 287–317. https://doi.org/10.1080/15569540802432308

Tanaka, A., Johnson, J.-M., Senthilkumar, K., Akakpo, C., Segda, Z., Yameogo, L. P., Bassoro, I., Lamare, D. M., Allarangaye, M. D., Gbakatchetche, H., Bayuh, B. A., Jaiteh, F., Bam, R. K., Dogbe, W., Sékou, K., Rabeson, R., Rakotoarisoa, N. M., Kamissoko, N., Mossi, I. M., … Saito, K. (2017). On-farm rice yield and its association with biophysical factors in sub-Saharan Africa. *European Journal of Agronomy*, 85, 1-11. https://doi.org/10.1016/j.eja.2016.12.010

Tang, E. N. Ndindeng, S. A., Bigoga, J., Traore, K., Silue, D., & Futakuchi, K. (2019). Mycotoxin concentrations in rice from three climatic locations in Africa as affected by grain quality production site and storage duration. *Food Science & Nutrition*, 7(4), 1274-1287. https://doi.org/10.1002/fsn3.959

Tiamiyu, S. A., Danbaba, N., & Ugalahi, U. B. (2014). Report of survey on rice production and post harvest practices in the lowland rice hub Ofenue and Nasarawa States of Nigeria. 50p.

Toukea, T. N., Asafor, C. H., Melie, F. M. N., Dongmo, V. H., & Djiokeng, F. R. (2021). Evaluation of Seed Quality along the Rice (*Oryza sativa* L.) Value Chain in Cameroon, Case of: Ndop, Tonga and Ebolowa Rice Farmer's Seeds. *International Journal of Current Research*, 13 (01), 15506-15511. https://doi.org/10.24941/ijcr.40591.01.2021

Wu, X. H., Wang, W., Yin, C. M., Hou, H. J., Xie, K. J., & Xie, X. L. (2017). Water consumption, grain yield, and water productivity in response to field water management in double rice systems in China. *Plos One*, 12(12), e0189280. https://doi.org/10.1371/journal.pone.0189280

Евалуација квалитета риже произведене у Мбаму, Камерун и њена повезаност са праксама прије и послије бербе

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Сажетак

Рижа је основна прехрамбена намирница у Камеруну, иако је њена производња релативно ниска да би задовољила локалне потребе за количином и квалитетом. Овај рад се бави евалуацијом тренутног стања физичке и физиолошке квалитете риже произведене у центрима за рижу у Мбаму. Извршена је процјена примјењиваних пракси прије и послије бербе уз помоћ упитника у оквиру истраживања током којег су прикупљени узорци риже од узгајивача. Физички и физиолошки параметри, укључујући клијавост, влажност, сортну чистоћу, незрела зрна, као и проценат напуклих, цијелих и сломљених зрна, испитивани су на узорцима риже у лабораторији уз кориштење специфичних инструмената и метода за евалуацију квалитете риже. Укупно је прикупљено 80 рандомизованих узорака риже, укључујући сјеме, неољуштену рижу и различите врсте ољуштене риже од произвођача риже на четири локације. Истраживањем се дошло до девет сорти риже (Nerica 8, Nerica L56, Touh-Mba, Tox3145, Madam, Nerica 3, Mbankou, Sophie и Bakala) које су узгајају на поменутом локалитету и три главна извора сјемена риже, наиме претходно убрана неољуштена рижа (69,2%), ољуштена рижа (23,1%) и оба извора (7,7%). Анализа физичких и физиолошких особина сјемена риже показала је значајан $P < 0,05$ пад у сортној чистоћи међу произвођачима у Бадоунги (81,94%) и Нуокону (77,39%) у поређенјњу са Нколбиссон (97,56%). Сличан тренд утврђен је за неољуштену рижу, премда са вишим износима (75 до 80%) напуклих зрна. Сломљена зрна у неолјљуштеној рижи су заузимала велике количине, 50,02 до 62,11%, мада су нечистоће биле ниске у свима узорцима риже <0,5%. Значајна корелација ($r = -0,93$, $P < 0,0001$) утврђена је између сортне чистоће неољуштене риже и нивоа сломљених зрна. Посматрано у цјелини физичка квалитета риже произведене на подручју Мбам је слаба, стога иновације добијене истраживањима треба да се на ефективан начин примијене ради унапређења.

Кључне ријечи: сјеме риже, неољуштена рижа, ољуштена рижа, квалитет, третман риже послије бербе.

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