



Physico-Chemical Characterization of Some Malagasy Rice Varieties. Relationship between Digestibility and Weevil Attack

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Abstract

Alkali digestibility and gel consistency of a few Malagasy rice varieties have been studied. As regard the alkali digestibility, results show three types of varieties: respectively varieties with low, medium and high alkali digestibility. Homogeneous translucent milled varieties are found to have a long time of unchangeableness at storage (more than two years): they were most of the improved irrigated rice. They agreed with low alkali digestibility (score 2 to 3) and they were difficult to be attacked by weevil. Most of the rainfed rice varieties were of intermediate alkali digestibility (score 3 to 5), and they have a semi-translucent caryopsis. High alkali digestibility (score 5.5 to 7) was among heterogeneous caryopsis rice (white belly rice, cracked rice, structured paddy). They are even though in the class of rice easy to cook on culinary consideration. They were remarkably easy to be attacked by weevils or fungi. Hybrid 885 retained water in the slot and was breakable as example. About gel consistency, most of the varieties were of hard gel consistency (score less than 40 mm). The low gel consistency (score more than 60 mm) was found with parboiled rice varieties and some varieties such as 27 GM, 28 GM, Man-jamena, which reflects a good culinary quality: tenderness longtime after cooking and cooling. In every case, varieties with a low gel consistency and easy to cook are highly sought varieties by urban consumers.

Subject Areas

Agricultural Science

Keywords

Alkali Digestibility, Gel Consistency, Structured Paddy, Fungi, Weevil, Homogeneous

1. Introduction

This study allows identifying the quick cooking rice varieties in selected varieties and those with soft consistency during cooling after being dry cooked.

Digestibility in alkali, and gel consistency are two significant characteristics in determining cooking quality of rice. The quick cooking rice has a major role to the burning issue of fuel economy. The soft gel consistency of rice is little known in Madagascar, although expressing the most appreciated quality of cooked rice tender after cooking, by urban consumers.

Beside these characterizations, our parallel studies have shown relationship between caryopsis tenderness and insect attack on milled rice, but also between fungal attack and furrowed or structured paddy. There was vulnerability of certain varieties to biodegradation: easy attack by weevils or fungi. To identify these two types of relationship, our experience was based on the determination of the alkali digestibility and physical observation of caryopsis grains.

2. Material

2.1. For Alkali Digestibility Test

- Milled rice varieties from traditional and improved varieties were used:
- *Irrigated varieties*: MR10734.7.2, MR10734 (Madera), MR10214, MR10253 (Marisika), MR10244 1.2.3, 1.1.1 MR10218, Mahasarika, X265 (Mailaka), 2067, X398 (Tsiresindrano), X372 (Kelimirefaka), X360 (Mahadigny), ON333 (Soafitsanga), Tox V5 (Vesainky), X1816 (FRX 92F3B-14F4BF6), X1818 (FRX 92F3B-6F4BF6), X1832 (IR 70422-99-1-5), X1833 (IR 70423-170-2-3), X1834 (IR 70444-87-2-1), X1842 (RPSC148), Basmati 370, Soameva, hybrid 914, 879 hybrid, hybrid 885, 27GM, 28GM, 18Br, Rojofotsy, Manjamena.
- *Rainfed varieties*: FOFIFA63, FOFIFA133 (Kanto), FOFIFA152 (Meva), FOFIFA153, FOFIFA157 (Malaky), FOFIFA159 (Mahaso).

2.2. For Gel Consistency

- *Rrigated varieties*: Soameva, ON333 (Soafitsanga), X265 (Mailaka), X372 (Kelimirefaka), X360 (Mahadigny), ToxV5 (Vesainky), 27 GM, 28 GM, 18 BR, Rojofotsy, short and sticky rice Tsipala, plain Rojomena, parboiled Rojomena, plain Manjamena.
- *Rainfed varieties*: Varieties: plain FOFIFA159 (Mahaso), parboiled FOFIFA 159 (Mahaso), 4129 (Meva), FOFIFA157 (Malaky), plain FOFIFA172, parboiled FOFIFA172.

3. Method

3.1. Alkali Digestibility Test



The test (**Table 1**) gives rice caryopsis hardness and its gelatinization temperature. The value was obtained from rice grains (N = 6) soaked in 10 ml of potassium hydroxide 1.7 (w/v) during 23 h at 30°C in triplicates. Variation was ob-

served with the naked eye according to the following scores [1]: 1 = unaffected grain, low alkali value; 2 = swollen grain, low alkali value; 3 = swollen grain, with narrow incomplete collar, intermediate alkali value; 4 = swollen grain with wide complete collar, intermediate alkali value; 5 = split grain with complete collar, intermediate to high alkali value; 6 = dispersed grain merging with collar, high alkali value; 7 = completely dispersed and intermingled grain, high alkali value. Lower scores correspond to harder grains. When gelatinization temperature is low [55°C - 69.50°C], this agrees with high alkali value (score 6 or 7), the grains are soft. The next scale is [70°C, 74°C] for intermediate and [74.5°C, 80°C] for high gelatinization temperature which corresponds to hard grains.

3.2. Gel Consistency

The gel consistency was defined by the length of cold gel in a horizontally held test tube for one hour. This was obtained from 100 mg of thin 60 mesh flour put in a test tube 13 × 100 mm, added with 2 ml of 0.2N aqueous potassium and some drops of thymol blue. A glass marble with the test tube width was used to

Table 1. Degree of digestion.

Degree of digestion	Alkali digestibility	Score	Figures
Unaffected grain	Low	1	
Swollen grain	Low	2	
Swollen grain, with narrow incomplete collar	Intermediate	3	
Swollen grain with wide complete collar	Intermediate	4	
Split grain with complete collar	Intermediate to high	5	
Dispersed grain merging with collar	High	6	
Completely dispersed and intermingled grain	High	7	

cover the solution. The whole was boiled during 8 minutes, and then cooled in an ice bath during 10 minutes before laying the test tubes on millimeter paper.

The values were classified as follow [2] [3]: $L > 61$ mm, soft consistency; $60 > L > 41$ mm: medium consistency; $L < 40$ mm: hard consistency.

4. Results

4.1. Alkali Digestibility

Alkali digestibility reflects the tenderness of the caryopsis and its easiness to cook. The grains may be speedy or long to cook according to the strength of alkali digestibility. Our test showed a strong alkali digestibility with Marisika, Vesainky, 2067, hybrid 885, Mahaso (greater than 5): grains were split with a comprehensive and broad collar; their gelatinization temperature is therefore low. These varieties were easy to cook.

Alkali Digestibility was found average with MR10244 1.2.3, MR10218 1.1.1, Mahasarika, hybrid 879, hybrid 914, Malaky, Kelimirefaka, FOFIFA153, Meva, FOFIFA63, Rojofotsy, (observed values between 4.70 and 3.70): grains swollen with wide complete collar. Most of rainfed analyzed varieties (Table 2) were noticed in this average digestibility (average values = 4.03), except the variety Mahaso (score 5.87). Their pasting temperature was in the intermediate value.

Regarding to irrigated varieties, we remarked that the caryopsis were homogeneous translucent. Their milled rice benefited to sustainable conservation according to our experiment (more than 2 years). These were: Mahadigny, Tsiresindrano, X1816 (FRX 92F3B-14F4BF6), X1818 (FRX 92F3B-6F4BF6), X1832 (IR 70422-99-1-5), X1834 (IR 70444-87-2-1), X1842 (RPSC148), Soafitsanga, Madera, MR10214, Mailaka; their alkali digestibility was low (2 to 3.17): (Table 3),

Table 2. Rainfed rice alkali digestibility.

Variety	FFF63	FFF133	FFF152	FFF153	FFF157	FFF159
A. D.	3.70	3	3.70	3.83	4.14	5.83

Table 3. Irrigated rice alkali digestibility.

(a)												
Variety	M734.7.2	M734	M214	M253	M244 1.2.3	M218 1.1.1	MHSRK	X265	2067	X398	X372	
A. D.	3.17	2	2	5	4	3.9	4	2.66	5.7	2.5	3.67	
(b)												
Variety	X360	ON333	Tox V5	X1816	X1818	X1832	X1833	X1834	X1842	Basm	RJF	Soameva
A. D.	2	2.5	5.17	2	2.07	2.5	2	2.5	2	4.5	4.17	3
(c)												
Variety	Hybr.914	Hybr.879	Hybr.885	27GM	28GM	18Br	MjM	RJM				
A.D.	3.70	4.70	5.83	5.50	3	4.5	5.0	2.5				

therefore, they were with a high gelatinization temperature. These varieties were longer to cook too.

Interpretation

The general tendency of the digestibility values (**Table 2** and **Table 3**) on the analyzed whitened rice was the intermediate digestibility (score 3 to 5). Few varieties were of high digestibility (score 5.83). The noted results confirmed the proportionality between the digestibility and the homogeneity of the caryopsis: when the rice caryopsis was homogenous, the digestibility with the potassium hydroxide solution 1.7% was weak (score 2 to 3); this fact made the rice sample in good state for much time storage. In the opposite, the heterogeneity gave high digestibility of the rice caryopsis (5 to 7). That referred to varieties difficult to preserve (weevil attack, broken rice, wet rice...). The digestibility was an indicator of the quality to storage of the whitened rice, and of the full rice grain also.

On the culinary option, the high digestibility of the rice caryopsis however meant that it was interesting in being quickly cooked. On the other side the homogeneous rice caryopsis was proved to give firm and elongated caryopsis on cooking [3]. So the alkali digestibility also provided an indirect index on the cooking and eating quality, similarly to the results obtained by Chemutai *et al.* [4].

4.2. Gel Consistency

The advantage of the gel consistency is to get information about the quality of the cooked rice after cooling. Generally, a hard gel consistency variety hardened after being cooked.

Soameva, Soafitsanga, Malaky, Meva, X265 (Mailaka), X372 (KELIMIREFAKA), X360 (Mahadigny), Basmati 370, Tox V5 (Vesainky), short size Tsipala, FOFIFA 157 (Malaky) were found in this case. Their average values were 30 mm to 40 mm.

The major values were inferior to 60 mm as seen in **Table 4** and **Table 5**. So most of the analyzed Malagasy rice varieties were of hard gel consistency; they hardened after cooking and cooling. Some varieties however were exceptions such as those from the Middle-East (27 GM, 28 GM, 18 BR: average value 83 mm), the red improved rice Manjamena (82 mm), the traditional rice Rojomena (65 mm), the traditional sticky rice Tsipala from the North-East (92 mm).

Table 4. Irrigated rice gel consistency.

Varie-ty	Soam	ON333	X265	X372	X360	Basm	ToxV5	RJF	ShTspl	SticTspl	Pl Rjm	parbRjm	Pl Mjm	27 GM	28 GM	18 Br
G.C. mm	28	28	30	28	30	33	28	65	30	92	65	60	82	95	60	94

Table 5. Rainfed rice gel consistency.

Variety	Pl F159	Parb F159	4129	F157	Pl F172	Parb F172
G.C. mm	30	70	30	40	40	60

On the other side, the parboiled rice varieties (parboiled Rojomena, parboiled FOFIFA 159, and parboiled FOFIFA 172) gave an ameliorating cooking and eating quality according to our determination; their gel consistency became at least medium (score value: 70 mm - 60 mm). Parboiled rice got elsewhere enrichment of nutritional values (minerals, proteins, fibers) [5] [6] [7] [8].

Interpretation

The medium gel consistency (60 mm - 65 mm) of the traditional varieties such as Rojomena and Rojofotsy was a value that would seem to explain the good taste of numerous traditional rice during the sensorial analysis [9]. Much more, the varieties 27 GM, 28 GM, 18 Br and Manjamena having values between 60 mm to 95 mm, were tasty and showed remarkably tender cooked rice after cooling. The Manjamena red variety within its soft gel consistency (value reaching 82 mm), confirmed its interest on culinary and nutritional point of view [5]. The parboiled varieties (Mahasoa, FOFIFA 172, Rojomena) gave a flow of medium to soft gel consistency (60 mm to 82 mm). This fact confirmed the improvement obtained in the cooking quality of parboiled varieties; the cooled rice after cooking was expected fairly to have moderate or low hardening.

The soft and medium gel consistency varieties were then interesting index on the culinary aspect and were characterizing elite rice to be developed. Especially when the amylose content was high ($\geq 24\%$), the soft gel consistency softened the cooked and cooled rice.

5. Relationship between the Caryopsis Tenderness and Their Attack by Insects

We have found three types of cultivars according their alkali digestibility: low alkali digestibility rice of score 2 to 3 (most of the irrigated and aromatic rice varieties), intermediate alkali digestibility rice with score 3 to 5 (the rainfed rice varieties, the hybrids and the Middle East rice varieties) and high alkali digestibility rice with score near to 6 till 7 (improved rice as Manjamena, 2067, Vesainky, and defective varieties of rice). The high alkali digestibility generally gave tender caryopsis which implies an easy attack by weevils; the low alkali digestibility was found among aromatic and irrigated varieties which were characterized by totally homogeneous translucency caryopsis, difficult to be attacked by weevils and the intermediate alkali digestibility divided into two groups: the first group was the rainfed varieties and some irrigated ones, which were white belly but possessed homogenous shape (**Figure 1**), and the second ones were the hybrids with furrowed paddy which owned defective shape (**Figure 2**).

There was easy weevil attack on the milled rice from grain of our following varieties which were of intermediate to high alkali digestibility: Mahasoa [10], Marisika [10], 2067, Vesainky (alkali value average was 5.42). These varieties showed faulty feature: white belly (**Figure 2**: hybrid 914), cracked caryopsis (**Figure 2**: Marisika), wet caryopsis, furrowed caryopsis, structured paddy (**Figure 2**: hybrid 879).

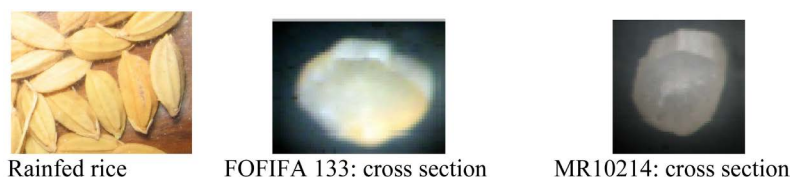


Figure 1. Varieties with homogeneous shape.

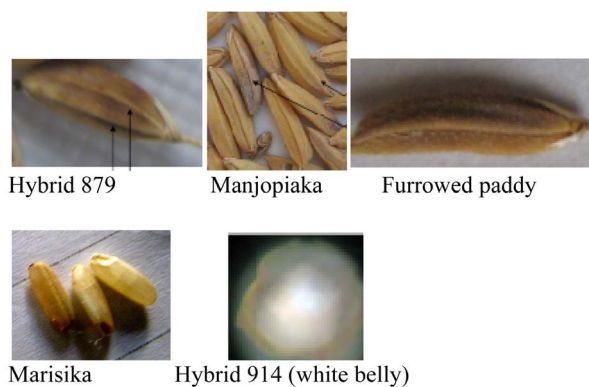


Figure 2. Varieties with faulty features.

But when alkali digestibility of milled grains was low, we noted more sustainable storage, they were not infected by weevils: Mahadigny, Tsiresindrano, X1816 (FRX 92F3B-14F4BF6), X1818 (FRX 92F3B-6F4BF6), X1832 (IR 70422-99-1-5), X1834 (IR 70444-87-2-1), X1842 (RPSC148), Soafitsanga, Madera, MR10214, Mailaka. These were generally aromatic varieties [11] with totally translucent grain.

Homogeneity of grain translucency is a criterion of stability and sustainability in the endurance to diseases, to weevils, to broken rice. This gives the rice a superior physico-chemical, nutritive and culinary quality.

6. Varieties with a Furrowed Structure

Alkali digestibility of the hybrids 914, 885 and 879 was medium to fairly high (3.70 to 5.83). That meant the caryopsis could be caught by external damages such as weevils, broken rice (Figure 2: Marisika), fungi (Figure 2: Manjopiaka), when the alkali digestibility is near to high (5.83 for Mahaso, as example).

The hybrid varieties were examples of cultivars with grooved structures (Figure 2: paddy). Paddy was visibly furrowed. The risk of deterioration occurred at a moisture grabbing the paddy. The acute grooves retained water and caused mold growth that embedded in the grain (Figure 2: Manjopiaka); consequently, they reduced the whole-grain yield and increased the chip rate; the molds contaminated the grain at the same time. The hybrid 885 was highly noted susceptible to fungi and mold was on the outer layer of paddy.

7. Conclusions

Quick cooking varieties and soft gel consistency are very popular, and have their

interest in our urban countries. Varieties with furrowed structure also benefit from being known for orientation of their growing area rather in dry zone.

As storage case, for water content 12% of the grain, two types of varieties have been found: those of a high translucency and a homogenous caryopsis, rice which was more interesting to preserve; this rice grain was characterized by a fairly weak alkali digestibility. The other type was characterized by heterogeneity of the caryopsis (white belly) or paddy (grooves presence). According to the case, that one could not stand up to damages: weevils, fungi or breaking, especially with a strong alkali digestibility more than 5.5 in the majority.

Our observation and experiences confirmed that homogeneity traduced an endurance of the variety to damages, and heterogeneity its easiness to deterioration. The alkali digestibility also expressed the degree of endurance of varieties to external damages as above.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Abbreviation Used for Varieties

M734.7.2: MR10734 7.2

M214: MR10214

M253: MR10253

M244: MR10244

M218 1.1.1: MR10218 1.1.1

MHSRK: Mahasarika

Basm: Basmati

RJF: Rojofotsy

Hybr.: Hybrid

MjM: Manjamena

FFF: FOFIFA

Soam: Soameva

Sh.Tspl: shortTsipala

Stic.Tspl: stickyTsipala

Pl.Rjm: Plain Rojomena

Parb.Rjm: parboiled Rojomena

Pl.Mjm: plain Manjamena

Pl.F.159: Plain FOFIFA159

Parb.F159: parboiled FOFIFA159

F157: FOFIFA157

Pl.F172: plain FOFIFA172

Parb.172: parboiled FOFIFA172

A.D.: alkali digestibility

G.C.: gel consistency