EVALUATION OF THE NUTRITIONAL AND SENSORY ATTRIBUTES OF TWO AROMATIC RICES VARIETES FROM NORTHERN MADAGASCAR "MOGODRO AND MADAME ROSE ".

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ABSTRACT

This study involved four white rice varieties, Mogodro, Madame Rose, Basmati, and Makalioka, focused on enhancing Madagascar's food resources by assessing the nutritional and sensory attributes of two aromatic rice varieties from the northern region. Nutritional analysis covered lipids, proteins, amino acids, carbohydrates, starch, amylose, amylopectin, essential minerals (P, Ca, Mg, K, Fe, Zn), and energy content. Culinary characteristics such as cooking time, grain expansion, and organoleptic properties like texture, smell, taste, and color were also studied. The results showed moisture content between 12.03% and 12.85%, lipid content from 1.13% to 2.26% DM, and protein levels ranging from 7.25% to 8.63% DM. The essential amino acids represented over 32% of total amino acids, with lysine being the limiting amino acid. Carbohydrate content varied from 88.93% to 91.04% DM, starch levels ranged from 78.01% to 89.22% DM, and amylose content varied between 18% and 30% DM. Ash content ranged from 0.47% to 0.63% DM. Mineral elements like iron and zinc were abundant (2-17 mg; 2-2.31 mg % DM), and the samples were also a good source of potassium and magnesium (97-178.67 mg; 56-84.25 mg % DM). The energy values ranged from 403.35 to 408.78 Kcal. All rice varieties cooked in 19 to 22 minutes, though the aromatic varieties expanded less than Makalioka. Sensory evaluations showed high appreciation for the texture, odor, taste, color, and overall quality, meeting the preferences of Malagasy consumers. Consequently, Mogodro and Madame Rose, despite being less available on the market, offer promising alternatives, enriching consumer choices and opportunities for Malagasy producers.

Keywords: *aromatic rice, Mogodro, Madame Rose, nutritional value, organoleptic quality, Madagascar*

1. INTRODUCTION

In recent years, the global market has witnessed an increasing demand for aromatic rice, particularly in Europe. Imported mostly from Asian countries, these rice varieties are known for their distinct fragrances, largely due to the compound 2-Acetyl-1-pyrroline (2AP), which gives them their signature "popcorn" flavor [1]. Rice holds a crucial place in Malagasy culture, with an annual consumption rate of 103 kg per person [2]. Despite modest income levels, the preference for rice is more dependent on its quality than its cost [3, 4]. While previous research has largely concentrated on increasing rice yield and resistance to pests and diseases. The present study continues the work conducted at LABASAN (Laboratory of Applied Biochemistry in Food Science and Nutrition) [4, 5, 6], which aims to assess the physical, nutritional, and sensory qualities of different rice varieties. Specifically, it focuses on two aromatic varieties from northern region of Madagascar, Mogodro and Madame Rose that are cultivated traditionally without the use of pesticides or chemical fertilizers.

2. MATERIALS AND METHODS

2.1 Plant Material

Four white rice samples: Mogodro, Madame Rose, Basmati, and Makalioka were selected. Basmati, renowned for its fragrance, and Makalioka, a luxury rice from Madagascar, were chosen for comparison. Biochemical analyses were conducted on rice flour obtained after grinding raw grains, while cooked rice was used for studying cooking behavior and sensory evaluation.

2.2 Biochemical Analyses

Moisture and ash contents were determined following the AOAC method [7]. Lipid content was assessed using the Soxhlet method with n-hexane [8] and protein content was quantified via the Kjeldahl method using a 5.95 conversion factor. Amino acids were analyzed according to Mossé's method [9]. Carbohydrate content was calculated by subtracting the amounts of protein, lipid, and crude ash from the total. Starch content was assessed using Ewers' polarimetric method [10], while amylose content was measured with the ISO 6647 standard colorimetric method [11]. The energy value was calculated using the Greenfield and Southgate method [12] applying Atwater coefficients. Mineral elements were analyzed as follows: iron, zinc, magnesium, and calcium were measured using atomic absorption spectrophotometry, phosphorus by colorimetry, and potassium by flame photometry.

2.3 Cooking Behavior

Cooking time was determined using the Ranghino method [13]. Swelling ratio was defined as the ratio of cooked to original rice weight.

2.4 Sensory Analysis

A trained panel of 17 members from LABASAN conducted sensory evaluations. The samples were cooked with a consistent water-to-rice ratio of 1.8. Evaluations focused on seven texture descriptors adapted from Rahanitrarivony's study [4], along with four additional organoleptic parameters: odor, taste, color, and hedonism. Each sample was presented sequentially, identified by a three-digit code, and assessed on a scale ranging from 1 to 9. The main objective was to discern differences among the characteristics of the various rice varieties.

3. RESULTS AND DISCUSSIONS

3.1 Nutritional Composition

Table 1 provides a summary of the results regarding the biochemical characteristics and energy values of the different types of rice analyzed.

Table 1: Nutrient contents and energy values

Rices Samples	Mogodro	Madame Rose	Basmati	Makalioka
Moisture (%)	12.03	12.85	12.43	12.62
Dry Matter (%)	87.92	87.15	87.57	87.38
Lipids (%DM)	1.13	1.84	1.47	2.26
Proteins (%DM)	7.25	8.63	7.91	7.85
Carbohydrates (% DM)	91.04	88.93	90.15	89.25
Starch (% DM)	89.22	86.94	78.92	78.01
Amylose (%DM)	23.11	10.23	21.84	15.21

Amylopectin (%DM)	66.10	76.83	57.07	62.81
Crude ash (% DM)	0.57	0.60	0.47	0.63
Phosphorus (mg %DM)	459.31	341.02	245.97	235
Calcium (mg %DM)	19.73	22.00	20.12	21
Magnesium (mg %DM)	67.08	84.25	70.04	56
Potassium (mg %DM)	97.19	178.67	98.03	97
Iron (mg %DM)	2.00	2.32	2.57	17
Zinc (mg %DM)	2.31	2.03	2.21	2
Energy value (Kcal)	403.35	406.80	405.49	408.78

mg % DM*: milligrams per 100 grams of dry matter*

- **Moisture and Dry Matter Content**

The moisture content of the samples ranged from 12.03% (Mogodro) to 12.85% (Madame Rose). These values comply with the standards established by CODEX STAN 198-1995 [14] for grain preservation and are comparable to those found in the literature [15,6]. In terms of dry matter content, these rates correspond to values ranging from 87.15% to 87.92%.

- **Mineral Value**

The crude ash contents of the investigated rices range from 0.47% to 0.63% DM, respectively for the Basmati and Makalioka samples. These results are consistent with those of Rahanitrarivony *et al.* [16] who reported values ranging from 0.36% to 1.15% DM and Rasoanaivo [5] who mentioned values between 0.44% and 1.67% DM. Regarding phosphorus, the samples exhibit high contents ranging from 235 mg % DM (Makalioka) to 459.31 mg % DM (Mogodro), similar to those reported by Sandratra Ny Avo [15], ranging from 169.03 to 426.12 mg % DM. However, concerning calcium, the samples are found to be poor, with contents ranging from 19.73 mg % DM (Mogodro) to 22 mg % DM (Madame Rose), lower than the average of 30 mg % DM reported by Sandratra Ny Avo [15]. For magnesium, the content varies from 56 mg % DM (Makalioka) to 84.25 mg % DM (Madame Rose), indicating that the samples are a good source of this element. Regarding potassium, Mogodro, Basmati, and Makalioka exhibit relatively similar contents around 97mg % to 98 mg % DM. However, Madame Rose stands out with a higher potassium content, reaching 178.67 mg % DM. As for iron, Mogodro, Madame rose, and Basmati display contents ranging from 2 to 2.57 mg % DM; however, Makalioka distinctly stands out with a much higher concentration, 17 mg % DM, highlighting its richness in iron. Finally, the zinc contents of the samples range from 2 mg % DM (Makalioka) to 2.31 mg % DM (Mogodro).

- **Lipid Value**

Cereals are generally classified among lipid-poor food groups. The lipid contents of the samples range from 1.13% DM (Mogodro) to 2.26% DM (Makalioka).

- **Carbohydrate Value**

The investigated rice samples exhibit high carbohydrate content, ranging between 88.93% to 91.04% DM, where starch predominates as the main constituent, representing 78% to 89% DM. Within the starch composition, amylose accounts for 10.23% to 23.11% DM.

- **Protein Value**

The protein contents of the samples range from 7.25% (Mogodro) to 8.63% DM (Madame Rose). These values are comparable to those documented by Rahanitrarivony *et al.* [16], 7.3 to 9% DM, and Sandratra Ny Avo [15], 7 to 10.5% DM.

Protein quality is determined by three factors: the amino acid composition, the proportion of essential amino acids, and the chemical index values of essential amino acids that define the performance score.
The analyzed rice varieties showcase proteins abundant in essential amino acids, accounting for 39.07% (Mogodro) to 39.54% (Madame Rose) of total amino acids (Table 2). These proportions surpass the FAO-recommended threshold of 32%, suggesting high biological value protein in the samples. Furthermore, these findings agree with the outcomes reported by Ralambofetra [17] and Rahanitrarivony [14], which recorded protein contents between 39% and 40%.

Table 2: Essential amino acid contents (% total amino acids)

Essential Amino Acids	Mogodro	Madame Rose	Basmati	Makalioka
Valine	5.66	5.84	5.75	5.74
Leucine	7.62	7.81	7.72	7.71
Isoleucine	3.87	4.03	3.96	3.91
Threonine	3.37	3.42	3.39	3.38
Lysine	3.86	3.76	3.80	3.81
Methionine + Cysteine	5.08	4.77	4.91	4.94
Phenylalanine + Tyrosine	9.61	9.91	9.77	9.75
Total	39.07	39.54	39.30	39.27

Chemical scores of essential amino acids compared with two reference profiles are presented in Tables 3 and 4.

Table 3: Chemical scores of the proteins in the samples according to the reference profile for children under two years old

Essential Amino Acids	FAO reference	Mogodro	Madame Rose	Basmati	Makalioka
Valine	55	102.90	106.18	104.54	104.36
Leucine	93	81.93	83.98	83.01	82.90
Isoleucine	46	84.13	87.61	86.09	85.00
Threonine	43	78.37	79.53	78.84	78.60
Lysine	66	58.48	56.97	57.57	57.73
Methionine + Cysteine	42	120.95	113.57	116.90	117.38
Phenylalanine + Tyrosine	72	133.47	137.64	135.69	135.42
Histidine	26	91.54	90.38	90.77	91.15
Tryptophan	17	68.82	70.00	69.41	69.41

According to the chemical scores of essential amino acids, lysine has the lowest index (57 to 58.5 < 66) compared to the needs of children under 2 years old and thus constitutes the limiting factor of proteins. Supplementation with protein sources rich in lysine such as legume proteins and those of animal origin is therefore desirable for their use in infant nutrition.

Table 4: Chemical scores of proteins in the samples according to the reference profile of children over two years old and adults

Essential Amino Acids	FAO reference	Mogodro	Madame Rose	Basmati	Makalioka
Valine	35	161.71	166.86	164.28	164.00
Leucine	66	115.45	118.33	116.97	116.82
Isoleucine	28	138.21	143.93	141.43	139.64

Threonine	34	99.12	100.59	99.70	99.41
Lysine	58	66.55	64.83	65.52	65.59
Methionine + Cysteine	25	202.30	190.80	196.40	197.20
Phenylalanine + Tyrosine	63	152.54	157.30	155.08	154.76
Histidine	19	125.26	123.68	124.21	124.74
Tryptophan	11	106.36	108.18	107.27	107.27

That lysine consistently exhibits the lowest chemical score, at approximately 65.5%, yet remains higher than the recommended nutritional needs for older children and adults, evaluated at 58, which is consistent with data reported for rice in general [17].

- **Energy Value**

The energy value of a food complements the information on its nutritional value. Each variety studied provides a certain amount of energy ranging from 403.35 to 408.78 Kcal. Makalioka is the most energetic of all the samples.

3. 2 Cooking Behavior

Cooking time is defined when the rice grain is transparent and completely free of whitish granules after being crushed between two glass plates [4]. Table 5 indicates the cooking time and swelling ratio of each rice sample studied.

Table 5: Cooking time and swelling ratio

Rices samples	Mogodro	Madame Rose	Basmati	Makalioka
Cooking time (min)	22	21	19	22
Swelling ratio	2.12	2.27	2.21	2.58

- **Cooking Time**

The minimum cooking time is for Basmati (19 min), while the Mogodro and Makalioka varieties have the same cooking time (22 min). These data indicate that the cooking times of all samples do not deviate from the usual rice cooking duration.

- **Swelling Ratio**

As for the swelling ratio, the studied samples present values ranging from 2.12 (Mogodro) to 2.58 (Makalioka), comparable to those of previous studies [15]. These results reveal that during cooking, the studied aromatic rices swell less than Makalioka rice.

3. 3 Sensory characteristics

A scale from 1 to 9 was used to rate the descriptors. Table 6 summarizes the mean scores assigned to the different descriptors by the judges.

Table 6: Average intensities of rice descriptors

Attributes	Mogodro	Madame Rose	Basmati	Makalioka
Grain scattering	6.00	7.50	7.50	7.00
Visual firmness	7.00	7.00	7.00	6.50
Deformed grains	0.00	0.00	1.00	1.50
Sticky during chewing	3.00	1.00	0.00	1.50
Firmness during chewing	7.30	6.23	6.27	6.00

Mast residue	0.00	0.00	0.00	1.00
Number of chews	4.50	4.00	4.00	4.00
Odor	6.18	6.13	7.50	1.00
Taste	5.13	5.65	5.43	5.77
Color	6.90	5.77	5.68	5.32
Hedonism	6.35	5.54	7.02	5.20

The obtained results reveal that all samples are visually and chewably firm, non-sticky, and require minimal chewing. Furthermore, Mogodro, Madame rose, and Basmati show no chewing residue or deformed grains, whereas for Makalioka, these values are very low. Thus, these results allow concluding that the rice samples were all appreciated by the tasters and possess most of the culinary qualities sought by Madagascar consumers, as per Rahanitrarivony's findings [4], who prefer firm, non-sticky, well-swelling, scatterable, and easy-to-cook rice.The scores assigned for aroma, taste, color, and hedonism are significantly above average (4.5), indicating that all rice varieties are well accepted and appreciated by the panel. The three aromatic samples stand out with a stronger aroma, with Basmati being more fragrant than the local varieties (7.50). Additionally, Mogodro, with its high color intensity (6.90), may suggest a distinctive visual appeal, which could be advantageous in the market. Compared to Basmati and Makalioka, which already have established reputations in the market, the study's interest in Mogodro and Madame Rose lies in their potential to offer interesting and innovative alternatives. They could be perceived as quality options, suitable for a range of taste and olfactory preferences, thus expanding consumer choice and offering new opportunities to Malagasy producers and distributors.

4. CONCLUSION

This study reveals that the analyzed rice samples possess interesting nutritional properties as well as organoleptic and culinary characteristics in line with the expectations of Madagascar consumers. These results contribute to a better understanding of the quality of aromatic rice from Madagascar and may also provide producers with guidance on the choice of varieties to cultivate. Consequently, the valorization of the cultivation of these aromatic rices can generate sustainable income for Madagascar farmers.

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