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Influence of Drying Areas on the Biochemical Parameters of Wita 9 Paddy Rice in the Main Production Areas of Daloa, Issia and Vavoua (Haut Sassandra Region of Côte d'Ivoire)

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Authors' contributions

This work was carried out in collaboration between all authors. Author KKB designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors KAC and DM wrote the protocol, managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background: Drying is a very important step in improving the quality of paddy rice.
Objective: The aim of this study is to determine the effect of different drying areas on the quality of the Wita 9 paddy rice grain samples.
Materials and Methods: A survey was carried out on the drying areas used and the duration of the operation. In addition, laboratory analyzes of samples of Wita 9 paddy rice grains taken after drying were carried out.
Results: The results obtained revealed the use of three types of drying areas by the producers, namely bag-tarpaulins, black tarpaulins and cemented areas. Preferably, pouch sheets are used by

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78% (Daloa), 62% (Issia) and 68% (Vavoua) by producers for drying paddy rice. Very few paddy producers surveyed do not reach the 7 days of drying as recommended. Analysis of variance showed significant differences ($p < 0.05$) regardless of the biochemical parameter considered. These observed variations show that these different types of drying areas have a significant effect on the biochemical characteristics of paddy rice samples.

Conclusion: It should be noted that the moisture contents (11.93 ± 0.60 -15.09 ± 0.07%), ash (5.06 ± 0.02- 5.88 ± 0.12%), protein (2.82 ± 0.70 - 4.57 ± 0.12%), fat (1.80 ± 0.07 - 2.99 ± 0.54%), carbohydrate (74.17 ± 0 , 58 - 76.78 ± 0.84%) and energy (325.75 ± 1.41-344.61 ± 3.21 kcal / 100 g) vary according to the different types of drying areas.

Keywords: Paddy rice; drying areas; biochemical characteristics; variations.

1. INTRODUCTION

Rice is a large grass that grows more easily in tropical climates. The cultivated species belong to the genus *Oryza*. The most represented are the species *O. sativa japonica* and *O. sativa indica* [1]. Rice is grown on five continents but its global production is largely concentrated on the Asia. China, India and Indonesia are the world's leading producers [2]. Rice is also produced in Africa, but especially in its western part where consumption is higher than production. In Côte d'Ivoire, rice has become the main food for most people. Due to its strong urbanization and relatively high population growth, rice consumption amounted to 1.3 million tons in 2008, while domestic production was estimated at 700,000 tons [3]. In Côte d'Ivoire, as in sub-Saharan Africa, rice is becoming increasingly important, in keeping with the strong growth of urban populations [4]. In the problematic context of increasingly crucial urban supply, rice is indeed a crucial commodity [5]. Rice in Côte d'Ivoire is present in all regions of the country, particularly the south and south-west. Accordingly, the characteristics of quality and general presentation of each variety of rice are of paramount importance. In addition, the chemical composition of rice (13% water, 2.1% lipids, 8.2% protein, 70 to 90% starch) [6] makes grain an important source of energy in human nutrition especially in developing countries. Thus constitutes a raw material for some industries [7]. At harvest, the high water content of rice (20% to 25%) [8] must be reduced in order to limit biochemical and microbiological reactions that often cause post-harvest losses. Water reduction reduces storage and transport costs and also improves the quality of husking. For the rice farmer, as this crop is a source of income and livelihood, a high yield of the variety is essential. For the miller the quality depends on the hulling rate and the breaking rate during milling. For the consumer and local producers, the quality of the rice grain is based on physical appearance, size and shape, cooking behavior and taste, tenderness and, in rare cases, the smell of the cooked rice [9]. Moreover, obtaining commercial rice goes through different technological stages, from harvesting to grain conditioning. Among them, drying remains one of the main operations [10]. Its essential role is dehydration of grains and requires the use of important energies [11]. Seen to its importance, the characterization of the various drying techniques and the determination of their influence on the physicochemical composition of the grains of paddy rice are envisaged by this work. The main objective of this study is to highlight the influence of the various drying areas used on the biochemical parameters of paddy rice in the main production areas of upper Sassandra in order to ensure a good conservation of this product.

2. MATERIALS AND METHODS

2.1 Study Areas

The study was carried out in the localities of Daloa, Issia and Vavoua in the Haut-Sassandra region (Fig. 1). This region is located in the center-west of Côte d'Ivoire, at latitude 6°15 N and 7° 45 N, and at longitude 6° and 7° W. It is bounded on the north by the Worodougou Region, on the east by the Marahoue region, on the west by the tonkpi and Guemon regions, and on the south by the Fromager and Bas Sassandra regions. It is also characterized by higher temperatures that can exceed 30°C. The average relative humidity is between 71 and 85%. Morever, the localities of Daloa, Issia and Vavoua represent respectively the three main areas of paddy rice production in the Haut-Sassandra region. This region is one of the major areas of intense paddy rice production, due to the high presence of large shallows for this

purpose on the one hand, and its high plant wealth on the other. The grains of the paddy (*Oryza sativa*) variety Wita 9 used in this work were taken from different drying areas of the rice producers of the localities.

2.2 Implementation of the Socio-Agricultural Survey

In order to appreciate the various technics used by producers to dry paddy rice in the Haut-Sassandra region, a survey was carried out in the localities of Daloa, Issia and Vavoua. For each zone, the starting point of the survey was the Chief town of the department. In order to ensure a good representativeness of the study area, the research of producers was done following the main axes emerging from these cities. Thus, in Daloa, the Daloa-Bouaflé, Daloa-Duékoué and Daloa-Issia axes were explored. In Issia, the Issia-Daloa and Issia-Gagnoa roads were followed. In Vavoua, investigations were carried out on the Vavoua-Daloa and Vavoua-Séguéla axes. On each main axis, the secondary axes leading to the small localities have also been explored. The present study was carried out on the basis of a structured questionnaire. In each selected locality, surveys were carried out by direct questioning of 90 paddy producers in Daloa, 70 paddy producers in Issia and 50 randomly selected paddy rice producers in Vavoua. A total of 210 paddy rice producers were interviewed. The aspects covered by the questionnaire concerned the surface used for drying, the duration of this post-harvest operation and the frequency of use of the drying areas.

2.3 Biochemical Analyzes of Wita 9 Paddy Rice Samples from Different Drying Areas

2.3.1 Sample collection and preparation of paddy rice

The samples of the Wita 9 paddy rice grains collected after drying by different techniques were subjected to a technological treatment which was summarized in several stages. The sorting that consisted of the removal of foreign matter (dead leaves, sand grains, straws, seeds of grasses, etc.) from paddy rice. After the sorting, the second stage concerned the winnowing. The purpose of the winnowing was to eliminate empty grains, dust, and other smaller particles that were forgotten or could not be seen by the eye. The third stage consisted

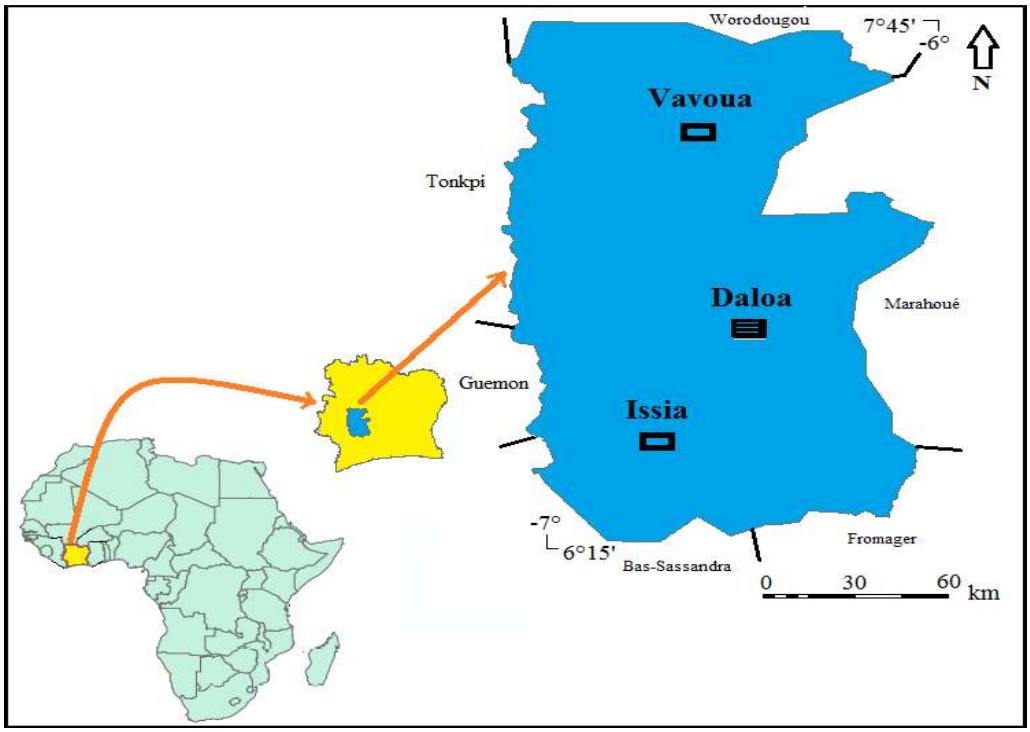

Fig. 1. Location of study area

in crushing the samples of paddy rice Wita 9 using a Moulinex type LM 2201 (made in China) until a crushed product was obtained. The various mills of the paddy rice samples obtained were packed and stored in hermetically sealed jars for possible analysis.

2.3.2 Chemical analysis

On paddy rice grain samples, biochemical parameters such as water, protein, ash, carbohydrate, fat and energy contents were determined. Moisture and ash content were evaluated using the AOAC method [12]. The protein content is obtained from the determination of total nitrogen, according to the Kjeldhal method [12]. The nitrogen content is multiplied by 6.25 (conversion coefficient of nitrogen into protein). The lipid content is determined according to the method described by AFNOR [13], using Soxhlet as extractor. Extraction of the oils is obtained by hexane in a Soxhlet extractor (Unid Tecator, System HT2 1045, Sweden). The total carbohydrate content was determined by calculation according to the following expression:

Total carbohydrate (%) = 100 - [ash (%) + protein (%) + fat (%) + moisture (%)].

The energy value was calculated taking into account the Atwater and Rosa coefficients [14] according to the following expression:

Energy value (kcal/100 g) = [(% carbohydrates x 4) + (% proteins x 4) + (% lipids x 9)].

2.3.3 Statistical analyses of data

The data collected from the survey and biochemical characterization of Wita 9 paddy grain samples from different drying areas were subjected to statistical analyses. Thus, a multidimensional analysis of variance was carried out in order to appreciate the existence of difference between the studied samples. In addition, analyses of variance were also performed on these data. Multiple comparison tests (Tukey HSD) were conducted when the difference was found to be significant ($p < 0.05$) to separate the different samples. To group the paddy rice samples according to their similarity, a hierarchical classification analysis was performed. Finally, the principal component analysis was carried out to visualize the differences and to associate the different identified groups with their main characteristics. For these statistical treatments, the STATISTICA 7.0 software was used.

3. RESULTS

3.1 Characterization of the Different Drying Areas of Paddy Rice

3.1.1 Type of drying areas and their frequencies of use

The results of the investigations revealed that the black tarpaulin, the tarpaulin in sack and the cemented area commonly called "terrace" are composed of three types of drying area mainly used for drying rice paddy Wita 9 in peasant environment (Fig. 2. Photographs a, b and c). The frequency of use of the various paddy rice drying areas by the producers is shown in Fig. 3. In general, it has emerged from the analysis of this figure that the bagged tarpaulins are preferentially used for the drying of the rice. paddy in all localities of the Haut-Sassandra region. In the locality of Daloa, bagged tarpaulins are frequently used for the drying of paddy rice by the producers with 78% of use. On the other hand, in this same locality, the producers have less use of the cemented area and the black tarpaulin for the drying of the paddy rice with a frequency of use respectively 4% and 18%. Concerning the Issia locality, for the drying of paddy rice, the trend of the producers would also be in the use of the tarpaulin in bag with a frequency of use of 62% against 34% of use for the black tarpaulin. Cemented areas are less used for drying paddy rice with a frequency of use of 4%. As for the locality of Vavoua, the producers used preferentially the tarpaulin in bag for the drying of rice paddy with a frequency of use 68% against 8% and 22% of use for the cemented area and the black tarpaulin. In these localities, producers rarely used cemented areas for drying paddy rice in the peasant environment (4%, 4% and 8% respectively used in Daloa, Issia and Vavoua).

3.1.2 Drying time

The duration of drying of paddy rice in the said localities of the Haut-Sassandra region would be different according to the producers and the production season. While some paddy producers place drying time between 1 and 3 days (69%, 57% and 78% respectively in Daloa, Issia and Vavoua), others estimated this duration between 4 and 6 days (21%, 23% and 12% respectively in Daloa, Issia and Vavoua). It should be noted that

very few producers have determined the drying time that they place beyond 6 days (10%, 20% and 10% respectively of Daloa, Issia and Vavoua).

3.2 Effect of the Different Types of Drying Areas on the Biochemical Characteristics of Wita 9 Paddy Rice Samples

3.2.1 Average biochemical composition of Wita 9 paddy rice samples from different localities

Tables 1a, 1b and 1c show the mean values of the biochemical parameters of the Wita 9 paddy rice samples from the three types of drying areas in the various localities. In the locality of Daloa (Table 1a), Wita 9 rice has an average humidity of around 13.00 ± 1.57%. In addition, with average ash levels of 5.65 ± 0.21%, protein 3.64 ± 0.58% and fat 2.20 ± 0.34%, Wita 9 rice contains total carbohydrate the order 75.52 ± 1.11%. In addition, consumption of Wita 9 rice provides on average an energy of 336.44 ± 8.15 kcal / 100 g. As regards the locality of Issia (Table 1b), Wita 9 rice contains average moisture contents of 12.12 ± 0.12%, ash of the order of 5.50 ± 0,36%, protein in the order of 4.01 ± 0.79% and fat on the order of 2.62 ± 0.42%. These rice are rich in carbohydrates (75.76 ± 0.77%) and energy (342.59 ± 2.51 kcal/100 g).

Photograph a). Drying on black tarpaulin

Photograph b). Drying on bagged tarpaulin

Photograph c). Drying on cemented area

Fig. 2. Various drying areas for paddy rice in the Haut-Sassandra region

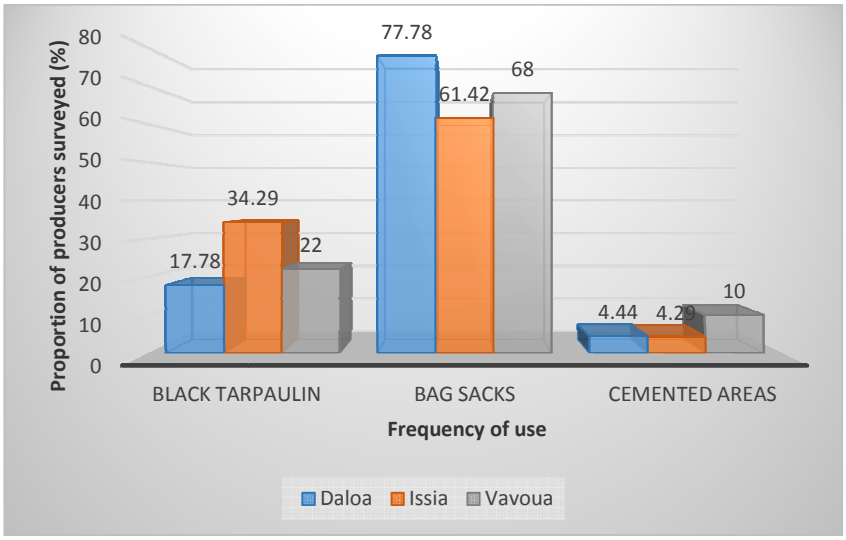

Fig. 3. Frequency of utilization of drying areas for Wita 9 paddy rice according to the three localities

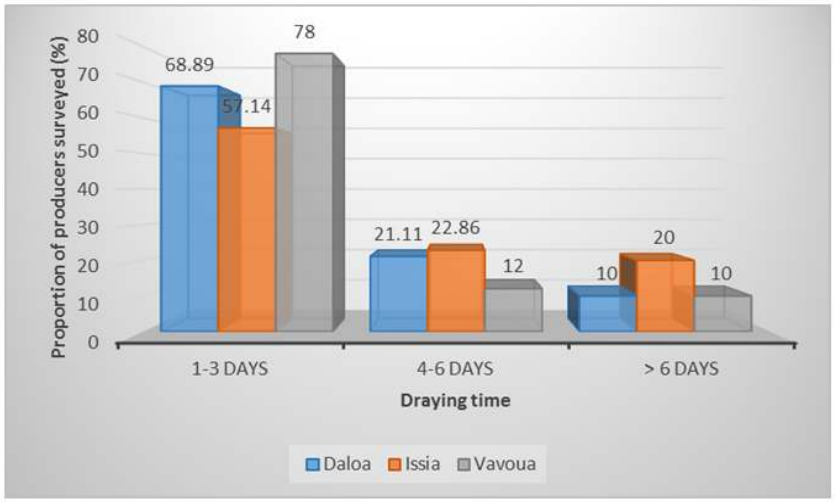

Fig. 4. Duration of drying of Wita 9 paddy rice in the three localities of the Haut-Sassandra Region

Table 1a. Average chemical composition of Wita 9 paddy rice samples taken from the locality of Daloa

	Locality of Daloa					
	N	**Minimum content**	**Maximum Content**	**Average content**	**Standard deviation**	**Coefficient of variation (%)**
Moisture (%)	9	11.87	15.16	13.00	1.57	12.07
Ash content (%)	9	5.31	5.99	5.65	0.21	3.77
Proteins (%)	9	2.90	4.62	3.64	0.58	15.98
Fat (%)	9	1.74	2.73	2.20	0.34	15.52
Total carbohydrates (%)	9	73.75	76.71	75.52	1.11	1.47
Energy (Kcal)	9	324.40	343.93	336.44	8.15	2.42

N: Number of samples

Table 1b. Average chemical composition of Wita 9 paddy rice samples taken from the locality of Issia

Locality of Issia						
	N	Minimum content	Maximum content	Average content	Standard deviation	Coefficient of variation (%)
Moisture (%)	9	11.91	12.25	12.12	0.12	0.96
Ash content (%)	9	5.05	6.00	5.50	0.36	6.56
Proteins (%)	9	2.70	4.70	4.01	0.79	9.72
Fat (%)	9	2.09	3.61	2.62	0.42	16.04
Total carbohydrates (%)	9	74.77	77.07	75.76	0.77	1.02
Energy (Kcal)	9	339.67	348.29	342.59	2.51	0.73

N: Number of samples

Table 1c. Average chemical composition of Wita 9 paddy rice samples taken from the locality of Vavoua

Locality de Vavoua						
	N	Minimum content	Maximum content	Average content	Standard deviation	Coefficient of variation (%)
Moisture (%)	9	12.06	14.04	12.75	0.85	6.63
Ash content (%)	9	5.19	5.80	5.58	0.19	3.44
Proteins (%)	9	2.27	4.85	3.75	0.86	22.82
Fat (%)	9	1.67	2.85	2.21	0.41	18.39
Total carbohydrates (%)	9	74.06	77.42	75.70	1.16	1.53
Energy (Kcal)	9	331.81	344.33	337.73	4.52	1.34

N: Number of samples

At the level of the Vavoua locality (Table 1c), Wita 9 rice contains average moisture content (12.75 ± 0.85%), ash (5.58 ± 0.19%), protein 3.75 ± 0.86%), fat (2.21 ± 0.41%). These rice are also rich in carbohydrates (75.70 ± 1.16%) and energy (337.73 ± 4.52 kcal/100 g). In addition, the average biochemical compositions of the twenty-seven samples of paddy rice Wita 9 (Table 2) are identical to those determined in each locality. The analysis of the coefficient of variation revealed that the most variable bioochemical parameters (CV> 15%) are the same regardless of the locality. These are the levels of lipids and proteins.

3.2.2 Differentiation between Wita 9 paddy rice samples according to the type of drying area used

A hierarchical classification of the Wita 9 paddy rice samples from the different types of drying areas in each locality was carried out. The results are shown in Fig. 5. Analysis of the dendrogram showed that there are differences between the Wita 9 paddy rice samples at the point where three classes can be distinguished:

- class 1 includes samples such as BNDaloa, ACDaloa, ACVavoua, BSIssia and ACIssia;
- the second class contains samples such as BNIssia and BNVavoua;
- and the third class is composed of BSDaloa and BSVavoua.

The grouping of Wita 9 paddy rice samples into three classes on the basis of their similarity makes it possible to summarize to 82.78% the differentiations between these rice varieties from the three types of drying areas. In addition, each class includes samples of paddy rice Wita 9 of different types of drying areas. The classes obtained are therefore quite composite. In addition, a multidimensional variance analysis was performed on the physicochemical characteristics of the rice samples of the different types of drying areas. The results obtained are shown in Table 3. The analysis shows that the effects of the drying areas are significant ($p < 0.05$) on all the characteristics of the Wita 9 paddy rice samples.

Table 2. Summary of average chemical composition of Wita 9 paddy rice samples

Parameters	N	Minimum content	Maximum content	Average content	Standard deviation	Coefficient of variation (%)
Moisture (%)	27	11.87	15.16	12.62	1.06	8.40
Ash content (%)	27	5.05	6.00	5.58	0.26	4.71
Proteins (%)	27	2.27	4.85	3.80	0.74	19.46
Fat (%)	27	1.67	3.61	2.34	0.42	18.07
Total carbohydrates (%)	27	73.75	77.42	75.66	0.99	1.31
Energy (Kcal)	27	324.40	348.29	338.92	5.99	1.77

N: Number of samples

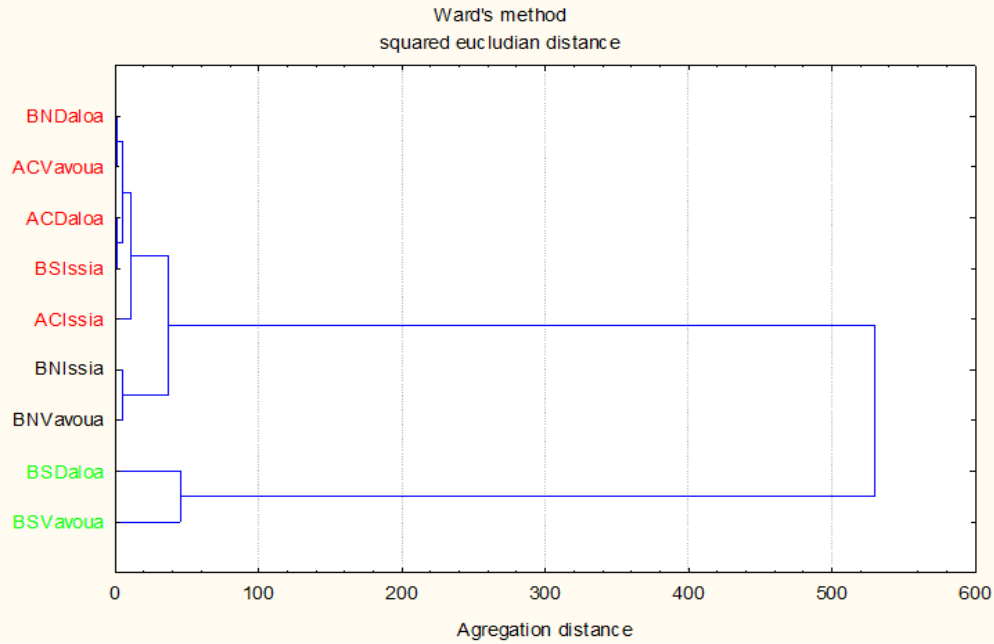

Fig. 5. Dendrogram of Wita 9 rice samples from the three types of drying areas

Table 3. Results of multidimensional variance analysis on the biochemical parameters of Wita 9 rice samples

Effect	Test	Value	F	Effect dl	Error dl	P
Drying areas	Wilk	0.000071	8	48	68.028	0.00000

The effects were significant at p <0.05

3.2.3 Comparison of biochemical characteristics of Wita 9 paddy rice samples according to the type of drying area used

Table 4 shows the average biochemical compositions of the paddy wita 9 samples taken from each type of drying area in each locality. Average moisture in paddy wita 9 rice samples ranged from 11.93 ± 0.60% for rice from the Daloa black tarpaulin (BND) to 15.09 ± 0.07% (rice from bagged tarpaulins of Daloa (BSD)). At the ash level, the average recorded grades of paddy rice Wita 9 ranged from 5.51 ± 0.38% for paddy rice from Issia bag bales (BSI) to 5.88 ± 0.12% (rice from Issia's black tarpaulins (BNI)). Similarly, protein levels ranged from 2.82 ± 0.70% (rice from the cemented Vavoua (ACV)) to 4.57 ± 0.12% for paddy wita 9 'Issia (BSI). Regarding the fat content of Wita 9 paddy rice, they ranged from 1.80 ± 0.07% (rice from Daloa sacks (BSD) to 2.99 ± 0.54% for samples taken from the cemented areas of Issia (ACI). Carbohydrate and energy values varied respectively from 74.17 ± 0.58% (rice from Daloa sacks (BSD)) to 76.78 ± 0,84% (rice from

cemented Vavoua (ACV)) and 325.75 ± 1.41% kcal / 100 g (rice from Daloa sacks (BSD)) to 344.61 ± 3.21% kcal / 100 g (rice from the cemented areas of Issia (ACI)). Moreover, the analysis of variance showed that all these variations were significant ($p < 0.05$) whatever the biochemical parameter considered of the different drying areas in the localities studied (Table 4). Therefore, all the biochemical parameters of the Wita 9 paddy rice samples studied (moisture, ash, protein, lipids, carbohydrates and energy) differ significantly (at 5% risk) depending on the type of drying area. The Wita 9 paddy rice samples from the cemented areas of Issia (ACI) and Vavoua (ACV) obtained the highest carbohydrate and energy levels (76.78 ± 0.84% and 344.61 ± 3.21 kcal / 100 g), followed by those from the black tarpaulins of Daloa (BND) (76.58 ± 0.18%) and those from the bag sacks of Issia (342.86 ± 0, 63 kcal / 100 g) while those from Daloa sacks recorded the lowest value (74.17 ± 0.58% and 325.75 ± 1.41 kcal / 100). At the fat level, the Wita 9 paddy rice samples from the cemented areas of Issia (ACI) and those of Vavoua (ACV) recorded the highest rates with respectively 2.99 ± 0.54% and 2.67 ± 0.20%. The Wita 9 paddy rice samples from Daloa sacks (BSD) obtained the highest moisture content (15.09 ± 0.07%). In addition, samples of Wita 9 rice from Issia sacks (BSI) and black tarpaulins from Vavoua (BNV) have virtually the same protein content. In addition, a principal component analysis was performed. The representation of the various rice samples from three types of drying areas of the said localities in a two-dimensional space is shown in Fig. 6. This makes it possible to visualize the differences between the rice samples coming from the three types of rice areas drying studied in a factorial plane (F1-F2). In this plan, which summarizes the differentiations to almost 82.78%, all rice samples from the types of drying areas are distinct, except those from the cemented areas of Issia (ACI) and Vavoua (ACV). The correlation circle of the variables (biochemical parameters) characterizing the rice samples originating from the drying areas of the localities is shown in Fig. 7. The first component (F1) is analyzed by parameters such as moisture, carbohydrates, energy value and fats whose coefficients are greater than 0.7 (in absolute value) while component 2 (F2) is defined by variables such as proteins and to a lesser extent ash. The comparative analysis of Figs. 6 and 7 revealed that rice samples from Daloa sacks (BSD) are characterized by its highest moisture content (15.09 ± 0.07%). In addition, rice samples from the Daloa cemented areas (ACD), the black and bagged sheets of Issia (BNI and BSI), and the black tarpaulins of Vavoua (BNV) are characterized by their high protein content. The rice samples from Daloa (BND), Daloa cemented areas (ACD), Issia bag bales (BSI), Issia cemented areas (ACI), black tarpaulins and cemented areas Vavoua (BNV and ACV)) are high in carbohydrates. As for rice samples from the black tarpaulins and cemented areas of Daloa (BND and ACD), black tarpaulins, bagged tarpaulins and cemented areas of Issia (BNI, BSI and ACI), and cemented areas of Vavoua (ACV), they have a very high energy value.

Table 4. Biochemical characteristics of Wita 9 rice samples from the three types of drying areas

Drying areas	Parameters					
	Moisture (%)	**Ash content (%)**	**Proteins (%)**	**Fat (%)**	**Total carbohydrates (%)**	**Energy value (kcal/100 g)**
BND	**11.93±0.60^{a}**	5.67±0.13^{a}	3.37±0.12^{a}	2.46±0.24^{a}	76.58±0.18^{a}	341.86±0.80^{a}
BSD	**15.09±0.07^{b}**	5.73±0.37^{a}	3.21±0.36^{a}	**1.80±0.07^{ae}**	**74.17±0.58^{b}**	**325.75±1.41^{b}**
ACD	11.98±0.12^{a}	5.54±0.07^{b}	4.33±0.26^{b}	2.35±0.19^{a}	75.82±0.24^{a}	341.72±1.41^{a}
BNI	12.22±0.01^{b}	**5.88±0.12^{a}**	4.48±0.02^{b}	2.54±0.05^{ab}	74.89±0.10^{cba}	340.31±0.66^{a}
BSI	12.12±0.12^{a}	**5.06±0.02^{c}**	**4.57±0.12^{bc}**	2.31±0.23^{a}	75.94±0.39^{a}	342.86±0.63^{a}
ACI	12.03±0.11^{a}	5.56±0.03^{b}	2.97±0.24^{a}	**2.99±0.54^{ac}**	76.45±0.58^{ad}	**344.61±3.21^{a}**
BNV	12.21±0.12^{b}	5.47±0.27^{b}	4.56±0.26^{bc}	1.81±0.13^{ac}	75.96±0.23^{a}	338.37±0.86^{ad}
BSV	13.86±0.22^{c}	5.74±0.06^{a}	3.87±0.27^{ab}	2.16±0.22^{a}	74.37±0.27^{db}	332.34±0.65^{c}
ACV	12.18±0.11^{a}	5.54±0.11^{b}	**2.82±0.70^{ad}**	2.67±0.20^{ad}	**76.78±0.84^{ae}**	342.46±1.74^{a}

Levels with identical letters in the same column are statistically identical (risk of 5%)

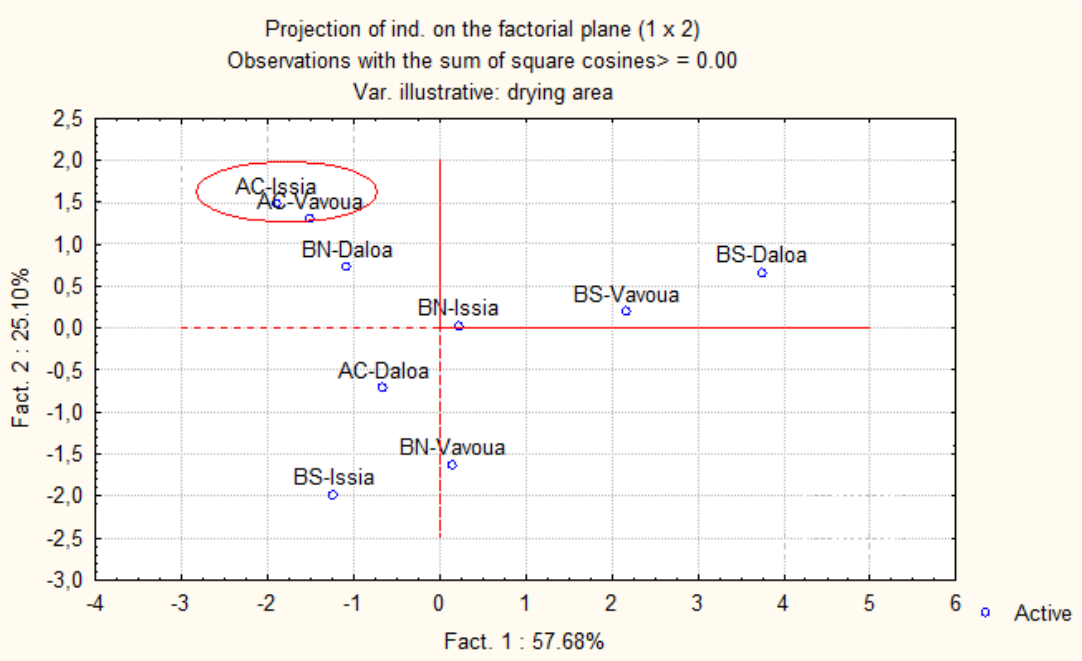

Fig. 6. Representation of the results of the principal component analysis performed on the Wita 9 rice samples of the three types of drying areas (factorial plan F1 -F2)

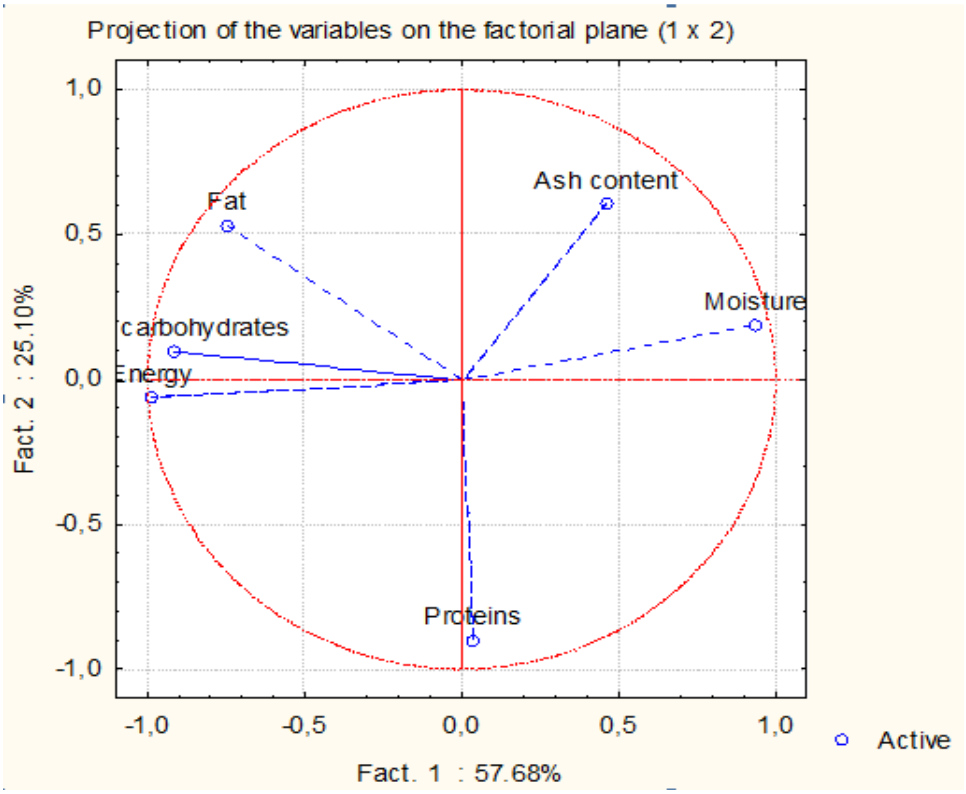

Fig. 7. Correlation circle between biochemical parameters

4. DISCUSSION

Drying is an important step in improving the nutritional quality of paddy rice. The investigation of the paddy rice producers Wita 9 in the localities of Daloa, Issia and Vavoua revealed that black tarpaulins, bag-tarpaulins and cemented areas commonly called "terrace" are the three types of areas of drying used for drying paddy rice in peasant environments. Their frequency of use varies from one locality to another. In addition, bag wraps, cemented areas and black tarpaulins are commonly used in general, although some variations are observed in terms of their frequency of use and therefore their preference. Thus, the preference of black tarpaulins and tarpaulins by the Yamoussoukro rice producers has been pointed out by Konan [15]. However, producers in the Haut Sassandra region preferentially use bag-tarpaulins (78%, 62% and 68% respectively in Daloa, Issia and Vavoua). The high use of bagged tarpaulins could be explained in part by the fact that this type of drying area would be used over several years. Moreover, its relatively low price also makes it a type of drying available to all paddy producers [16]. Note that the drying mode used by the producers surveyed is solar drying. This must be done at least 7 days as recommended. Indeed, a large proportion of the producers in the various localities do not respect this length of time accurately. This is reflected in the fact that some paddy producers place the drying time between 1-3 days and others between 4-6 days. Very few paddy rice producers surveyed do not reach the 7 days as recommended. In addition, failure to meet recommended drying times could contribute to the depreciation of the nutritional quality of Wita 9 paddy rice. Drying is an important phase in post-harvest operations and influences the conservation of the product from an essential parameter which is the water content [6]. The influence of three types of drying areas on the biochemical characteristics of Wita 9 rice samples was determined. This study indicated that the biochemical composition of the Wita 9 rice samples from the three types of drying areas showed significant differences. Moreover, the analysis of variance showed that the differences observed were significant ($p < 0.05$) whatever the biochemical parameter considered of the samples of Wita 9 rice of the different drying areas in the localities studied. The observed results show a variation in the biochemical parameters of the rice samples from the different drying areas. These observed variations show that these different types of drying areas have a significant effect on the biochemical characteristics of the Wita 9 rice samples. Thus, moisture contents (11.93 ± 0.60 - 15.09 ± 0.07%), ash (5.06 ± 0.02- 5.88 ± 0.12%), protein (2.82 ± 0.70 - 4.57 ± 0.12%), fat (1.80 ± 0.07 - 2.99 ± 0.54%), carbohydrates (74.17 ± 0.58 - 76.78 ± 0.84%) and energy (325.75 ± 1.41-344.61 ± 3.21 kcal / 100 g) vary depending on the different types of drying areas. As a result, from one sample of Wita 9 rice to another, the values of these characteristics vary significantly, resulting in differentiation depending on the type of drying area. Differences between the Wita 9 paddy rice samples as a function of the type of drying areas visualized by main component analysis (PCA) showed that all rice samples from the types of drying areas are distinct, with the exception of those from the cemented areas of Issia (ACI) and Vavoua (ACV). Drying of paddy rice is carried out in order to lower the moisture contents to 12 to 15% depending on the storage time [17,18]. Thus, according to this author and this organization, a paddy moisture level higher than this value could favor a high proportion of breakage during the hulling and on the other hand cause a development of the molds that would affect the quality of the husked rice. It should be noted that the different moisture contents of the different Wita 9 rice samples (11.93 ± 0.60 - 15.09 ± 0.07%) from the three types of drying areas in Daloa, 'Issia and Vavoua are relatively close to those advocated by FAO [18] and Cruz [17]. It should be noted that samples of Wita 9 rice from the three types of drying areas in these localities showed protein levels lower than those obtained by Saliou [19] on paddy rice in Senegal. The work carried out by this author in Senegal showed that paddy rice has a protein proportion of 6.38%. In general, the ash, protein, fat, carbohydrate and energy levels of the Wita 9 rice samples according to the three types of drying areas differ from one sample to another. Very few samples of Wita 9 rice from the three types of drying areas have the same grades. However, samples of Wita 9 paddy rice from the three drying areas have ash, fat, protein, carbohydrate and energy content as recommended by FAO [8]. It should be noted that solar drying under direct natural convection using black tarpaulins, bag tarpaulins and cemented areas remains the most widespread method of preserving food products [19]. However, it presents an important problem related to a lack of control over the evolution of the water content in the grain to reach that appropriate for good conservation [6].

5. CONCLUSION AND SUGGESTION

Drying of Wita 9 paddy rice in the main production areas of Daloa, Issia and Vavoua in the Haut-Sassandra region is generally carried out on three types of drying areas. These are black tarpaulins, tarpaulins and cemented areas. However, paddy producers preferentially use tarpaulins as a drying area in the three localities of the Haut-Sassandra region. The results obtained in the laboratory show a variation in the physicochemical parameters of the rice samples from the various drying areas. As a result, from one sample of Wita 9 rice to another, the values of these characteristics vary significantly, resulting in differentiation depending on the type of drying area. For example, moisture contents (11.93 ± 0.60 -15.09 ± 07%), ash (5.06 ± 0.02-5.88 ± 0.12%), protein (2.82 ± 0.70 – 4.57 ± 0.12%), fat (1.80 ± 0.07 - 2.99 ± 0.54%), carbohydrate (74.17 ± 0.58 - 76, 78 ± 0.84%) and energy (325.75 ± 1.41-344.61 ± 3.21 kcal / 100 g) vary with the different types of drying areas. These observed variations show that these different types of drying areas have a significant effect on the physicochemical characteristics of Wita 9 rice samples.

Consequently, it is essential to consider regular sensitization to paddy rice producers by introducing the right drying technics and by insisting on the respect of the recommended drying duration. Also, an improved dryer should be installed in order to obtain paddy rice with the best physicochemical characteristics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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