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Effect of storage period of paddy rice on grain fissures and breakages of milled rice

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Abstract: *The study was carried out to determine the effect of storage period of paddy rice on grain fissures and breakages of milled rice. Two locations - Minna, Niger State and Gombe, Gombe State were selected for the experiment. Samples were collected from storage silos using sample probes with inbuilt vacuum pressure to suck grain samples from the consignment. The samples were taken to laboratory for analysis. Data obtained were subject to analysis of variance using the General Linear Model Procedure of the function of statistical analysis system (SAS version 9.0). Means were separated using the Duncan Multiple Range Test (DMRT) at 5% level of probability. The result of analysis revealed that the superior fissured and broken grains obtained from milled rice stored between 1-2 years in this study was an indication of better quality. The result of analysis revealed that even though the design of the milling machine was good, good quality paddy rice (with uniformly matured kernels, uniform size and shape) a minimum of empty or half filled grains, a minimum of stones and weed seeds contributes to good quality of all milled rice. High temperature and relative humidity have a lot of impacts on the quality of milled rice, they accounts for an expansion and contraction of paddy rice in storage which also contributed to fissuring and breakages in milled rice. The major determinant of grain fissures and breakages was long storage periods of paddy rice. Hence, short storage periods of paddy rice was recommended to minimize fissures and breakages of milled rice.*

Keyword: *Fissures, Humidimeter, Physico-chemical, Consumer preferences*

I. Introduction

Rice (*Oryza sativa* L.) for the past decades has taken a prominent position as an international crop and an economic growth for majority of nations of the world. According to Saka and Lawal (2009) and Food and Agriculture Organization (FAO) (2000), rice is one of the most important food depended upon by over 50% of the world's population for up to 80% of their food need. It has been estimated that annual rice production needs to be increased from 586 million metric tons in 2001 to meet the projected global demand of about 756 million metric tons by 2030 (Keuneman, 2006). This was due to the growing importance of rice and the increasing challenges of the attainment of food security (FAO, 2002). FAO (2006) reported that there was a growing demand for rice in Africa. This is an evidence of pressure on the world supply and the steady increase in the world price of the commodity. Africa, the report said, has become a gigantic actor in international rice markets, accounting for 32% of global imports in 2006, at a record level of 9 million tonnes. Africa's emergence as a big rice importer is explained by the fact that during the last decade rice has become the most rapidly growing food source in sub-Saharan Africa (Awotide, *et. al.*, 2012). Owing to population growth (4% per annum), rising incomes and a shift in consumer preferences in favor of rice, especially in urban areas (Seck, *et. al.*,, 2012), the relative growth in demand for rice is faster in this region than anywhere in the world.

Rice production from 2001-2005, has been expanding at the rate of 6% per annum, with 70% of the production increase due mainly to land expansion and only 30% is attributed to an increase in productivity (Dontsop, *et. al.*, 2011). Much of the expansion has been in the rainfed systems, particularly the two major ecosystems that make up 78% of rice land in West and Central Africa (WCA): the upland and rainfed lowland systems. Nonetheless, demand for rice in WCA has far outstripped the local production. Somado and Guei (2007) quoting - CIRAD's Observatory of International Rice Statistics - as saying that Africa cultivated about 9 million hectares of rice in 2006 and a production, which surpassed 20 million tons for the first time, is expected to increase by 7% per year in future.

In West Africa, where the rice sector is by far the most important in sub-Saharan Africa (SSA), the situation is particularly critical. Despite the upward trends in international and domestic trade rice consumption is increasing at a rate of 8% per annum, surpassing domestic rice production growth rates of 6% per annum, the production-consumption gap in this region is being filled with imports, valued at over US$ 1.4 billion per year (Somado and Guei, 2008). The share of imports in consumption rose from an average of 43% from 1991-2000, to an average 57% by 2002-2004. The Food and Agriculture Organization of the United Nations estimated that current rice imports into the WCA sub-regions had grown to more than 6 million tons costing over $1.00 billion (in scarce foreign exchange) each year. The cost of importing rice therefore remains a heavy burden on trade balances in the region.

Justification

Storage environment has great influence on the quality of milled rice. Temperature and relative humidity for instance, enables paddy grains to dry relatively quickly during the day resulting to contraction of the grain but readsorb moisture at night accounting for grain expansion (Cnossen, 2000). These conditions provoke transverse fissures in the grains and increase breakages during milling and also a reduction in nutritional contents of grains.

The duration of storage of paddy rice grains is a major determinant of good quality of milled rice. Hence, paddy rice processed after a period of storage recorded a low nutritional content and was vulnerable to grain fissures and breakages.

Aim and Objectives

The aim of this study was to determine the effect of storage periods of paddy rice on grain fissures and breakages, and physico-chemical properties of rice.

Specific Objectives

i. To determine the degree of fissured and broken grains after milling;
ii. To determine the effects of storage periods of paddy rice on the chemical composition after milling.

II. Materials And Methods

Experimental Materials

The paddy rice samples used were collected from the Strategic Grain Reserve Silos in the two locations – Minna, Niger state and Gombe, Gombe state.

Experimental Design

A completely randomized design was used and replicated three times. The replication was a collection of the paddy rice samples at three spots in each silo. The treatment was the period of storage of paddy rice (1, 2, 3, 4 and 5 year).

Data Collection

All samples were taken with the sample probes from the silo and labeled accordingly on the basis of the year of harvest and the site of storage. The sample probe has an inbuilt vacuum pressure which enables it to suck grain samples from the consignment. Collected samples were then weighed out to 400 grams for the physical laboratory analysis and 20grams was also weighed for proximate analysis.

Parameter Collected

The parameters collected for laboratory analysis:

- Fissured grains. Grain moisture content. Broken grains. Damaged grains
- Temperature of grains. Carbohydrate content. Crude protein. Crude fibre.
- Crude fat. Moisture content. Ash. Moisture Content and temperature **(%)**

The moisture content was determined by using Humidimeter (Farmex MT-Promoisture meter). The following steps were followed :-

-The cap/cover was removed and the test machine was clean and empty.

-The trail was filled with the right quantity of the sample (400g)

-The button on the tester was pressed, then the display showed the names of various/ difference grains.

- The name of grain to be tested was selected using the arrows on the screen (for this particular study paddy rice was selected).

- The button on the tester was Pressed, then the machine computed and displayed the results of the moisture content, temperature and the hectolitre weight of the grains at the same time.

Fissured grain percentage:

After milling, fissured grains were sorted out manually by hand with aid of a laboratory magnifying lens. The percentage of fissured grain was then determined using the formula below (NFRA, 2011);

$$\frac{\text{Quantity of broken grains}}{\text{Total quantity of sample}} \times 100$$

Broken grain percentage:

The broken grain was sorted out from the milled sample manually by hand using a magnifying lens. The lens magnifies the images of the smaller breakages for proper sorting. The percentage of broken grain was determined using the formula above.

Percentage of damaged grains:

This was done manually by hand with the aid of a lens and determined using the same formula above.

The procedures for proximate analysis

Proximate analysis was carried out to determine the nutritional content of food, feed, plants etc. This analysis was conducted for crude protein, crude fibre, crude fat, ash, carbohydrate and moisture content of the grains as follows.

Crude protein determination.

This test was carried out to know the percentage of crude protein in the sample and was in accordance with the method used by Unwuka (2005).

Determination of crude fibre,

This test was carried out to know the amount of fibre in a sample and the method was in agreement with Ibitoye (2005).

Determination of crude ash

This test was carried out `to know the percentage of inorganic component of the sample, and the method was in accordance with Ibitoye (2005)

Determination of crude fat

This analysis was carried to know the amount of fat in a given sample.

Determination of moisture content

This analysis was carried out to ascertain the amount of moisture in a giving sample.

Statistical Analysis

Data obtained were subjected to analysis of variance using the General Linear Model Procedure of the function of statistical Analysis System (SAS version 9.0). Means were separated using the Duncan Multiple Rang Test (DMRT) at 5% level of probability.

III. Results And Discussion

Fissured grains

The effect of storage periods of paddy rice on fissured grain of milled rice at Minna, Gombe and the combined means is shown in Table 2. The result indicated that storage period had a significant effect on this parameter in each location and the combined means. The storage of paddy rice above 3 years resulted in a significantly higher fissured grains than the lower years in both locations and the combined means (Table 4.1).

Broken Grain

The effect of storage period of paddy rice on broken grains of milled rice at Minna, Gombe and the combined means (Table 4.2). This parameter differed significantly due to storage period, such that milled grains obtained from paddy stored up to 5 years resulted in significantly higher number of broken grains than each of the lower years, which were in turn greater than each other except those stored at 2 and 1 year at Minna. Similarly, at Gombe, paddy grains stored above 3 years resulted in similar higher number of broken grains than the lower years. However, the combined mean indicated that paddy grains stored up to 5 years resulted in significantly higher number of broken grains than those at 3 and 4 years which were similar, and 1 and 2 years which were also similar.

Damaged Grains.

The effect of storage periods of paddy rice on damaged grains of milled rice at Minna, Gombe and combined Means is shown in Table 4.3 This parameter was not significantly influenced by the period of storage in each location and the combined means (Table 4.3).

Moisture Content of Grain.

The effect of storage periods of paddy rice on grain moisture content of milled rice differed significantly in Minna, Gombe and the combined means (Table 4.4). At Minna and Gombe highest moisture content was obtained when grains were stored up to 1 year, though not significantly different with other years except 5 years. Furthermore, at Gombe, similar trend was recorded with the combined means.

Temperature of grains

The effect of storage periods of paddy rice on grain temperature of milled rice at Minna, Gombe and the combined means, this parameter was not significantly different between the storage period in each location and the combined mean, except in Minna. (Table 4.5)

Carbohydrate Content of Grain

The effects of storage periods of paddy rice on carbohydrate (CHO%) content of milled rice at Minna, Gombe and the combined means. Result from Minna shows that there were significant differences in all the years. One year storage had the highest value (79.14%), while storage period of five year had the lowest value (64.16%) (Table 4.6)

Similarly at Gombe, paddy rice stored at 1-2 years resulted in a significant higher percentage of carbohydrate than the higher years. Year 3-5 were not significantly different from each other. The result of the combined mean differed significantly at 1-5 years due to the effects of storage periods. However, higher carbohydrate content was recorded at 1 year of storage than each of the lower year which was in turn higher than each other significantly.

Moisture Content of Grain

The effects of storage periods of paddy rice on the moisture content of milled rice at Minna, Gombe and the combined means. At Minna, the highest moisture content was recorded when paddy rice was stored at 1 year, the result also indicated that there was no significant different at 2-3 years of storage. However, the moisture content was significantly different at 4-5 years of storage (Table 4.7). At Gombe, paddy rice stored at 1-2 years was significantly higher than those at 3-5 years. The highest value was from storage periods of 1 year. However the means indicated that paddy rice stored up to 5 years were significantly lower than other years.

Crude Protein Content

The effects of storage periods of paddy rice on crude protein content of milled rice at Minna, Gombe and the combined means (Table 4.8). At Minna, higher crude protein was recorded at 1 year of storage periods while the lowest crude protein was recorded in Minna at 5 years. However, there was no significant difference between the storage periods at 3-4 years. At Gombe, the results of the parameters were significantly different at 1-5 years of storage except at 3-4year which were not significantly different from each other. However, the highest crude protein was recorded at 1 year of storage period while the lowest was recorded at 5 years. Similarly, the combined means indicated a significantly higher crude protein at 1 year of storage. However, the results at 3-4 years were not significantly different from each other (Table 4.8).

Crude Fibre Content

The effects of storage periods of paddy rice on the crude fibre content of milled rice at Minna, Gombe and the combined means (Table 4.9). These parameters differed significantly in Minna, Gombe and the combined means due to storage periods of paddy rice. The results indicated that the highest crude fibre was recorded at 1 year while a low crude fibre of milled rice was recorded at 5years. The results of the parameters were not significantly different from each other at 2- 4 years at Minna.

At Gombe, the highest crude fibre was recorded at 1 year of storage period. The results of the parameters were not significantly different from each other at 2-3 and 4-5 at Gombe. The results of parameters for the combined means indicated no significant different was recorded at 3-5 years of storage, which were in turn different from other years with the highest crude fibre recorded at 1 year (Table 4.9).

Crude Fat Content

The effects of storage periods of paddy rice on crude fat content of milled rice at Minna, Gombe and the combined means. At Minna, the results of the parameters indicated that highest crude fibre was recorded at 1 year of storage while the lowest crude fibre was recorded at 5 years. However, 2-4 years of storage were not significantly different from each others in Minna (Table 4.10).

At Gombe, paddy rice stored at 1-2 years were not significantly different from each other and 4-5 years were also not significantly different from each other except at 3 years. The highest crude fat was recorded at 1 year while the lowest was at 5 years. The results of the combined means indicated that storage of paddy rice, showed significant different from 1-5 years of storage except at 3-4 of storage. However, the highest means was recorded at 1 year of storage and the lowest was recorded at 5 years (Table 4.10).

Ash Content of Grain

The effects of storage periods of paddy rice on ash content of milled rice were not significantly different at Minna, Gombe and the combined means (Table 4.11).

IV. Discussion

Grain fissures revealed variation due to storage periods in the two locations of storage. Higher values of fissures obtained at longer years of storage could be due to the effects of heat and relative humidity accounting for expansion and contraction of paddy rice which may eventually result to grains fissures. This result agrees with the report of Thompson (2006) who stated that rice kernel fissures when they are exposed to high relative humidity after they have been dried below critical moisture content.

Broken grains showed higher percentage of breakages in the two locations of storage due to the effects of storage periods which may allow the grains to fissure. Fissures weaken grains kernel and during milling, kernels with fissures tends to break easily leading to the broken grain fraction in the milled rice. This result agrees with Sieben (2000) who reported that any grain kernel with cracks were vulnerable to breakages during milling.

Moisture content decreases at both silo locations of Minna and Gombe may be due effects of storage periods accounting for shrinkage of grains while in storage. However, any fresh storage (that is the very season harvest) would always record a high percentage of moisture content, but as the storage periods progresses and environmental factor such as temperature played its role, a declining percentage of moisture content was recorded at both locations and the combined means. This result agrees with the report of Mushira (2005) who stated that grains in storage continued to undergo natural drying and this was exhibited through difference in moisture content at intake and disposal periods.

The temperature of the grain did not indicate much significant effect of storage periods on milled rice at each location and the combined means. This was due the fact that the grain was stored under a controlled storage structure and such parameter was monitored carefully using the Temperature Monitoring Unit (T.M.U) on the control panel. The slight difference at one (1) year of storage at Minna may be as a result of operational/technical challenges. This result agrees with National Food Reserve Agency (NFRA), (2009) that says temperature does not have much effect on the stored grain under a controlled storage structure except where an operational or technical challenges was recorded (e.g break down of aeration system, erratic power supply for aeration e.t.c).

Carbohydrate content was decreasing as the storage periods progresses; this was due to the fact that the activities of storage insects were on the increase. These insects feed on the grains contents; thereby lessen the CHO content of the grains. This report agrees with that of NFRA (2009) which says that the longer the periods of grain storage, the higher the activities of storage insect (except under a controlled storage structure) and the more the grain continued to lose its contents.

On the crude protein, the result indicated variations in the percentage of crude protein due to the effects of storage periods in the two locations of storage. This decreasing percentage may be due to activities of insects which might have eaten up the vital protein content of the grains. This is in agreement with NFRA (2009) which stated that the longer the storage of grains, the lower the percentage of nutrient content of such grains.

Similarly, the result on fat content of milled rice in both locations showed a declining percentage of fat due to the effects of the storage period. This was due to fact that the grain itself do respire and in the process release heat , this metabolic activities of grain under storage tends to create cracks on the grains resulting to leakage of vital content such as the fat. Thompson (2002) also stated that when grain is exposed to sun too long, cracks may be created leading to leakage of vital contents.

Crude fibre content showed a high percentage of fibre at one (1) year storage at each location and the combined means. Subsequently, a decreasing percentage of fibre was recorded at each location and the combined means as the storage periods progresses due to the effect of storage periods. The activities of insect tends to increase as the storage periods progresses, hence vital nutritional components were always eaten up by storage insects resulting to a declining percentage in the constituents of the grain. This report agrees with that of NFRA (2009) above.

V. Conclusion

Based on the finding of this study, paddy rice stored for longer periods generated high percentage of fissures and broken grains than the lower years. The result of the study revealed that paddy rice stored for 1 year produced a better quality crude protein, crude fat and crude fibre in both locations than storage at longer periods.

Conclusively, storage period of paddy rice for one year gives better result of good quality milled rice that would be accepted by consumers.

VI. Recommendations

- From the result of this study, it is recommended that paddy rice should be stored at few number of years (1 - 2 years) to avoid/minimize fissures and breakages of milled rice.
- For high quality of crude protein, crude fibre, crude fat, grains should be stored for 1 year.
- Similar study should be conducted on other crops of their stock (such as maize, sorghum, millet, soya beans.) in order to have good quality food commodities that will be appreciated by consumers.

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Table 4.1: Effect of storage periods of paddy rice on fissures of milled rice

	Fissured grain (%)		
Storage (year)	**Minna**	**Gombe**	**Mean**
1	1.04^{b}	0.62^{b}	0.83^{b}
2	1.69^{b}	1.38^{b}	1.54^{b}
3	5.70^{a}	5.72^{a}	5.71^{a}
4	5.04^{a}	6.01^{a}	5.53a
5	5.40^{a}	6.08^{a}	5.74^{a}
SE±	0.33	0.38	0.26

Means of the same letter in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 4.2: Effect of storage periods of paddy rice on broken grains of milled rice

	Broken grains (%)		
Storage (year)	**Minna**	**Gombe**	**Mean**
1	1.08^{d}	0.887^{b}	0.98^{c}
2	1.49^{d}	1.25^{b}	1.37^{c}
3	2.99^{c}	6.93^{a}	5.57^{b}
4	4.92^{b}	6.21^{a}	5.57^{b}
5	7.31^{a}	6.52^{a}	6.92^{a}
SE±	0.34	0.38	0.27

Means of the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 4.3: Effect of storage periods of paddy rice on damaged grain of milled rice

	Damaged grain (%)		
Storage (year)	**Minna**	**Gombe**	**Mean**
1	0.42[a]	0.13[a]	0.27[a]
2	0.05[a]	0.38[a]	0.22[a]
3	0.11[a]	0.16[a]	0.13[a]
4	0.14[a]	0.15[a]	0.15[a]
5	0.21[a]	0.13[a]	0.17[a]
SE±	0.15	0.12	0.10

Means of the same letter in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 4.4: Effect of storage periods on moisture content of milled rice

	Moisture content (%)		
Storage (year)	**Minna**	**Gombe**	**Mean**
1	10.07[a]	9.68[a]	9.87[a]
2	9.02[a]	9.80[a]	9.41[a]
3	8.63[a]	9.39[a]	9.01[a]
4	8.64[a]	8.77[a]	8.71[a]
5	7.4[b]	7.67[b]	7.55[b]
SE±	0.66	0.57	0.43

Means of the same letter in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 4.5: Effect of storage period of paddy rice on temperature of milled rice

	Temperature (^oC)		
Storage (year)	**Minna**	**Gombe**	**Mean**
1	35.33[b]	24.67[a]	30.00[a]
2	34.67[a]	26.67[a]	30.67[a]
3	30.67[a]	26.67[a]	28.67[a]
4	35.00[a]	28.33[a]	31.67[a]
5	31.00[a]	21.00[a]	29.00[a]
SE±	1.83	1.22	1.11

Means of the same letter in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 4.6: Effect of storage period of paddy rice on carbohydrate (CHO)% content of milled rice

	Carbohydrate		
Storage (Year)	**Minna**	**Gombe**	**Mean**
1.	79.14[a]	74.79[a]	76.96[a]
2.	74.05[b]	72.70[a]	73.38[b]
3.	73.36[c]	69.67[b]	71.51[c]
4.	70.20[d]	67.24[b]	68.72[d]
5.	64.16[e]	67.67[b]	65.91[e]
SE±	0.18	0.76	0.36

Means of the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 4.7: Effect of storage period of paddy rice on moisture content of milled rice.

Storage (Year)	**M. S (%) Minna**	**Gombe**	**Mean**
1.	7.48[a]	7.09[a]	7.28[a]
2.	6.32[b]	6.94[a]	6.63[b]
3.	5.95[b]	5.88[b]	5.92[c]
4.	4.99[c]	5.10[c]	5.05[d]
5.	4.11[d]	4.41[d]	4.26[e]
SE±	0.26	0.12	0.19

Means of the same letter in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

M.S = Moisture Content.

Table 4.8: Effect of storage period of paddy rice on crude protein of milled rice.

Storage (Year)	**Crude Minna**	**protein (%) Gombe**	**Mean**
1.	11.17[a]	10.79[a]	8.64[a]
2.	9.49[b]	10.17[b]	7.66[b]
3.	7.88[c]	9.71[b]	6.52[c]
4.	7.41[c]	8.65[c]	6.42[c]

5.	5.18^{d}	7.54^{d}	4.76^{d}
SE±	0.28	0.16	0.21

Means of the same letter in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 4.9: Effect of storage period of paddy rice on crude fibre of milled rice.

	Crude fibre(%)		
Storage (Year)	**Minna**	**Gombe**	**Mean**
1.	6.89^{a}	6.11^{a}	6.50^{a}
2.	5.43^{b}	5.83^{b}	5.63^{b}
3.	4.97^{b}	5.64^{b}	5.31^{c}
4.	4.96^{b}	4.97^{c}	4.97^{c}
5.	4.46^{c}	4.74^{c}	2.31^{c}
SE±	0.17	0.08	0.15

Means of the same letter are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT).

Table 4.10: Effect of storage period of paddy rice on fat of milled rice

	Fat (%)		
Storage (Year)	**Minna**	**Gombe**	**Mean**
1.	7.50^{a}	7.02^{a}	7.26^{a}
2.	6.22^{b}	6.93^{a}	6.58^{b}
3.	6.14^{b}	6.43^{b}	6.28^{c}
4.	5.99^{b}	6.03^{c}	6.01^{c}
5.	5.05^{c}	5.96^{c}	5.51^{d}
SE±	0.24	0.11	0.21

Means of the same letter in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 4.11: Effect of storage period of paddy rice on ash

	Ash (%)		
Storage (Year)	**Minna**	**Gombe**	**Mean**
1.	2.80^{a}	2.99^{a}	6.80^{a}
2.	2.33^{a}	2.88^{a}	6.25^{a}
3.	2.17^{a}	2.67^{a}	5.94^{a}
4.	2.12^{a}	2.55^{a}	5.39^{a}
5.	2.07^{a}	2.56^{a}	4.81^{a}
SE±	0.25	0.15	0.11

Means of the same letter in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

APPENDIX I

Plate.1. A photograph of the Measuring Scale used in this study.

Plate 2. Sample of a grain seeker used for collection of paddy grains samples.

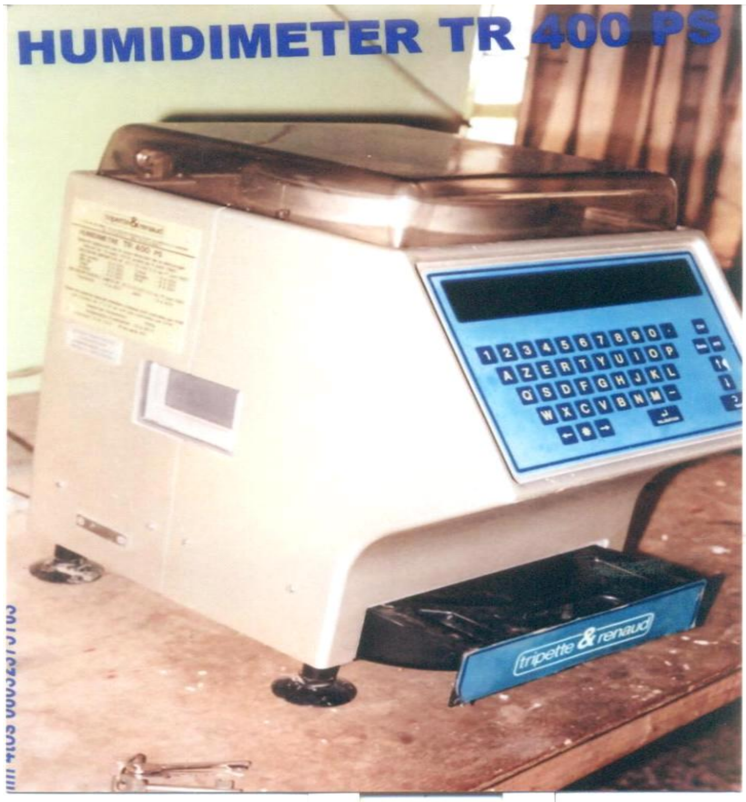

Plate 3. Humidimeter used to determine weight, moisture content and the temperature of paddy rice grains.

Plate 4. A picture of silos, where the experiment was conducted.