Development Of Computer-Aided Management For Grain Storage In Nigeria

Bayode J. Olorunfemi
Department of Mechanical Engineering,
Federal University Oye- Ekiti, Nigeria

Samuel B. Adejuyigbe
Department of Mechanical, Automotive and Production Engineering,
Elizade University. Ilara-Mokin Nigeria

Ogbeide, S.O
Department of Mechanical Engineering Department,
Ambrose Alli University, Ekpoma, Edo State.

Hezekiah O. Adeyemi
College of Engineering and Environmental Studies,
Olabisi Onabanjo University
Ago-Iwoye, Ogun State, Nigeria

Adeyemi A. Adekunle
Department of Mechatronic Engineering, Federal University Oye- Ekiti, Nigeria

Sunday E. Kayode
Department of Agricultural Engineering, Federal University of Technology, Akure, Nigeria.

***Abstract*—The objective of this work was to develop a computer- aided management system to minimize post-harvest grain losses at the storage level in Nigeria. Questionnaires were administered and analysed to determine the conditions of Federal Government metal silos and warehouses. Software was designed for a comprehensive grain stock management system (GSMS) to handle all activities at grain storage; this was validated at a case study silo complex. Storage activities were developed into eight modules having grain arrival, sampling, loading, stock management, aeration, pest management, equipment maintenance and storage management. The software developed had three major sections: the user interface was developed using Dreamweaver 8, coding section was developed using Pre-processor Hypertext Programme (PHP) code, and Database was developed using MySQL. Standard storage parameters used were; Moisture content (≤ 12%), Hectolitre weight (65- 75 Kg/Hl), Insect damage (≤ 1%), Mould damage (≤ 1%), and Foreign matter content (≤1%). Daily temperature and moisture content of the stored grains were obtained and computed for monitoring. Application of the software would save time by 66 % (two- third of manual operation), as the moisture content increases, mould proliferations grow faster (> 10^{0}C), it is more accurate and energy saving. Communication with all storage users was possible at every point of grain management because it is web based. GSMS would reduce losses from national's allowable 5 % to ≤ 1 %. Computer aided management is considered the most appropriate technology to solve major administrative and technical problems associated with grain storage in Nigeria**

Keywords—Computer-aided, Grain, Storage, Silo, Management

INTRODUCTION

Storage of durable produce has been in practice in various ways since the inception of farming. The development of an appropriate food production, storage, distribution and marketing strategies continue to be of utmost importance to Nigeria's aspiration for the attainment and sustenance of national food security. Prior to 1970, when the Nigerian economy was predominantly agriculture based, there was apparent balance in food supply and demand, and even a thriving export market for cash crops [1].This picture has however changed considerably because of the takeover of the economy by petroleum activities in the oil rich golden seventies and the attendant expansion of the construction, manufacturing and services sectors. The resultant effect is that agricultural production, though increasing at the reported rate of 3% was however unable to have the desired impact on the economy. This was due majorly to field losses, and post-harvest losses as a result of inadequate storage and processing facilities. In spite of this huge agricultural potential, Nigeria, which used to be the major player in agriculture in the world, has lost its place in the global agricultural market [2]. The Nigeria's farm production efforts still have to be matched with adequate attention on storage, marketing and

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distribution. In this context, any effort at increasing agricultural production must be matched with equal if not greater effort at producing adequate and efficient storage facilities and good management in order to ensure availability of food material at relatively stable price throughout the year, both for domestic consumption and for export [1].

The predominance and importance of grains in Nigeria in terms of seasonal production, production potential and consumption demands make storage an imperative task for all [3]. Every unit of product saved from post-harvest losses translates into an added unit available for productive utilization, including household consumption, at a time when global food security is under threat from shrinking arable land and variation in climate change [4]. Post-harvest technology can be said to be the most important aspect of food production. Post-harvest losses in threshing, transport and storage are estimated by UNIDO (1979) to be from 20-40 %, storage losses alone are 5% while food losses are estimated to be between 10- 60 % depending on the type of food material [1]. Moisture is one of the primary factors that affect the rate of grain spoilage in storage [5]. The quality of grain stored can only be maintained but not improved on during storage [6]. According to [7] losses is recorded throughout the grain chain (Figure 1).

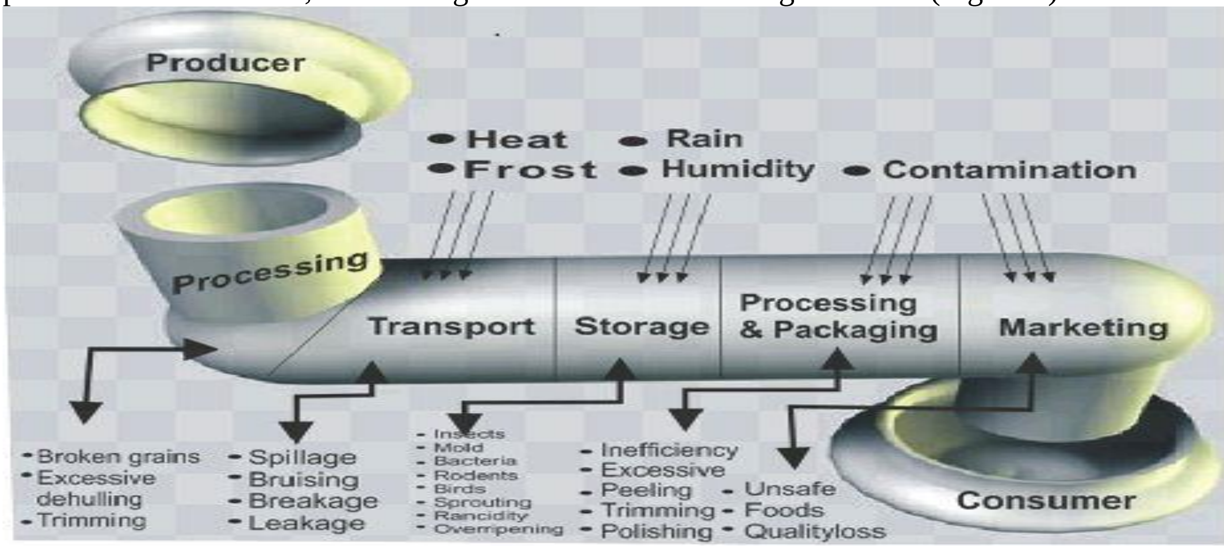

Fig. 1. The Grain Pipeline [8].

The use of commodity storage is an ancient idea. For instance in the Holy Bible, Genesis Chapter 41- 47 [9] informs us that the Egyptians operated an “ever- normal granary”, storing food during the seven years of plenty and then releasing these during the Seven years of famine. Classical China also operated commodity buffer stocks-particularly under the consolidation during the Sui dynasty in the 7th century [10]. Production of crops cannot provide the answer to the problem of self-sufficiency, because sudden increase in crop production exerts strains on existing methods of harvesting, handing and storage [11]. It is strongly believed that the major problem militating against food security in Nigeria is not the production but post- harvest operations [12,13].

Currently, the Department of National Strategic Grains Reserves of Nigerian Government has twelve (12) completed and functional silo complexes offering a combined storage capacity of 261, 000 metric tonnes. With the current efforts of the Federal Ministry of Agriculture at increasing agricultural production through Agricultural Transformation Agenda [14] and the Growth Enhancement Scheme (GES), twenty (20) silo complexes are presently been constructed across the country with a combined capacity of 1,025,000MT on completion [15]. This is in line with Food and Agriculture Organization (FAO) of United Nations recommendation that a country should have a food security programme which provides 20kg of grains per capital for 28days in the event of a natural disaster. The realization of this target in Nigeria implies a storage capacity of 3.2 million tons of grains for population of over 160 million [16].

Modern storage and preservation system is scientific, technological, complex, skilled, logistical and financially intensive. The modern system incorporates the principles of good management; such as moisture reduction and temperature monitoring. Computer Aided Management (CAM) is the integration of computers into the design, monitoring and production process to improve productivity [17, 18]. The 5% allowance for losses at the Federal Government storage silos would be reduced to <1%.

Relevance of the study

Application of grain storage management software developed will prevent major losses in the grain storage chain, thereby saving the cost incur from losses and manpower wastage. The 5% allowance for losses by the Federal Government of Nigeria at the National storage facilities could be reduced to as low as 1%. Corrupt practices will also be prevented when the application is properly applied. The Food and Agriculture Organization (FAO) of United Nations recommended a food security programme which provides 20 kg of grains per capital for 28days in the event of a natural disaster. The realization of this target in Nigeria implies a storage capacity of 2,215 million tons of grains for population of over 180 million. Every unit of product saved from post-harvest losses translates into an added unit available for productive utilization, including household consumption, at a time when global food security is under threat from shrinking arable land and variation in climate change [4].

Material and Methods

Personal visits were made to some of the locations of the National Strategic Grain Reserves Silo Complexes of the Federal Ministry of Agriculture and Rural Development of Nigeria, to obtain first-hand information about the prospects, problems and other essential challenges that they have. The following locations were visited; Minna, Makurdi, Ezillo, Irrua, Lafiagi, Gaya, Jahun, Kano Warehouse, Ibadan, Ilorin, Jos, and Akure silo storage complexes (all in Nigeria). General problems were observed as well as peculiar problems associated with each location. The location of Ondo state silo locations at Akure and Ondo towns were investigated, as well as that of Oyo State, Nigeria. Figure 2 shows an example of a cluster metal silo for storage of grains.

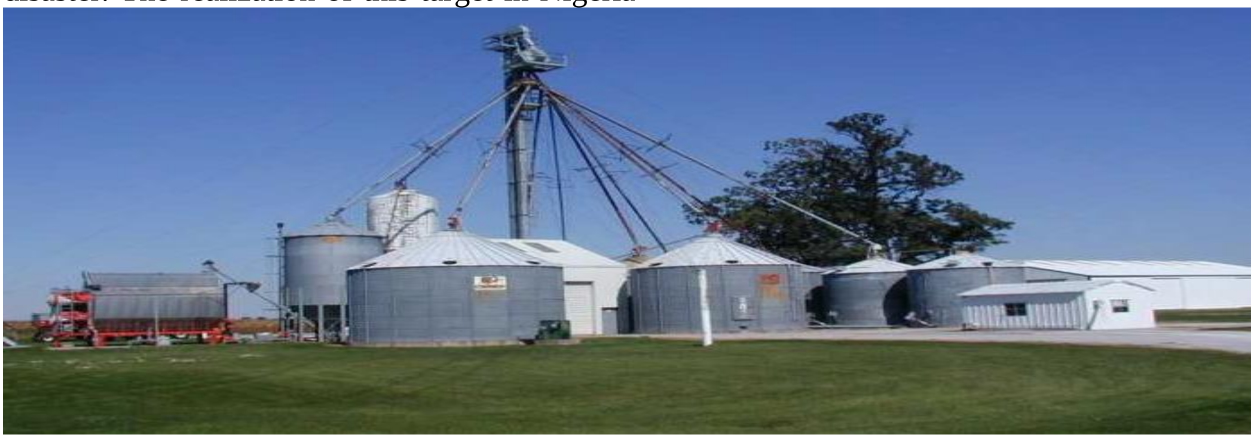

Figure 2. Cluster of metal silo system (Source:19)

Assessment of Existing Grain Storage facilities

Questionnaire was drawn to assess the conditions and position of some available silo storage system in the country. Information and general views of grain users; grain merchants, farmers, suppliers, middlemen, and consumers were also generated. Questionnaire was administered to fifty (50) participants, while the valid ones were used, the invalid ones were disregarded. The analytical tool used for the analysis of the questionnaire was descriptive statistics. The data was analysis with SPSS. The descriptive statistics used was frequency and ranking order. This in turn organized the data and identified the problems and developments of grain storage in Nigeria.

Development of Modules for Different Stages of Grain Management

The activities of the research was developed into eight modules having grain arrival/supply, sampling, loading, stock management, aeration, pest management, equipment maintenance and the storage management.

Module One: arrival of grain consignment at the silo location

Module one comprises of all operations that are involved in the reception of grain into the National grain storage complex. Queue theory was introduced for the analysis of grain arrival operations. The basic characteristics of the queue theory that was employed (FIFO) included:

a. Truck arrives at irregular intervals of time at the silo complex.
b. One or more suppliers are reaching the silo complex at a time. If the station is free (first to come at a time) the customers will be served immediately.
c. Customer- the arriving truck will requires some service to be performed. The customer may be the driver, supplier, truck, Bedford (10tons truck), etc.
d. Queue (waiting time) -this is the number of customer waiting to be served.

Expected number of unit in the system (waiting + being served)

$$L_s=\left(1-\frac{\lambda}{\mu}\right)\left(\frac{\frac{\lambda}{\mu}}{\left(1-\frac{\lambda}{\mu}\right)^2}\right)=\frac{\frac{\lambda}{\mu}}{\left(1-\frac{\lambda}{\mu}\right)}=\frac{\lambda}{(\mu-\lambda)} \qquad (1)$$

Expected numbers of units in the queue,

$$Lq=\left(\frac{\mu-\mu+\lambda}{\mu(\mu-\lambda)}\right)=\frac{\lambda}{\mu}.\frac{\lambda}{\mu-\lambda} \qquad (2)$$

Expected time per unit in the system i.e. expected time in a unit spends in the system

$$W_s=\frac{Expectednumberofunitinthesystem}{Arrivalrate}=$$

$$\frac{L_s}{\lambda}=\frac{\lambda}{(\mu-\lambda)\lambda}=\frac{1}{(\mu-\lambda)} \qquad (3)$$

Expected waiting time per unit in the queue, $W_q= W_s-\frac{1}{\mu}=\frac{1}{\mu-\lambda}-\frac{1}{\mu}=\frac{\lambda}{\mu}.\frac{1}{\mu-\lambda}$ (4)

Variance of queue length is

$$\frac{\lambda/\mu(1+\lambda/\mu)}{(1-\lambda/\mu)^2}-\frac{\frac{\lambda^2}{\mu^2}}{(1-\lambda/\mu)^2}=\frac{\lambda/\mu}{(1-\lambda/\mu)^2} \qquad (5)$$

Average length of non-empty queue Ln, for a non-empty queue, should be at least 2 (one being served and the other in the queue) $L_n=\frac{Averagelenghtofqueue}{probofnon-emptyqueue}=$

$$\frac{\frac{\lambda}{\mu}.\frac{\lambda}{\mu-\lambda}}{\left(\frac{\lambda}{\mu}\right)^2}=\frac{\mu}{\mu-\lambda} \qquad (6)$$

Average waiting time in non-empty queue (expected waiting time per busy period)

$$W_n=\frac{1}{\mu-\lambda} \qquad (7)$$

Notations for equations (eqn. 1- 7) used for the analysis are summarized as follows**:**

n= Number of customers in the system (waiting line + service facility) at line tλ

λ= Mean arrival rate (number of arrival per unit of line)

μ= Mean service rate per busy server (number of customers served per unit of time)

L_q= Expected (average) number of customers in the queue.

L_s= Expected number of customers in the system (waiting + being served)

W_q= Expected waiting time per customers in the queue

W_s= Expected time a customer's spend on the system (in waiting + being serve).

L_n= Expected number of customers waiting in line excluding those times when the line is empty i.e. expected number in non-empty queue (expected number of customers in a queue that is formed from time to time).

W_n= expected time a customer wait in line if he has to wait at all i.e. expected time in the queue for non-empty queue.

Module Two: Grain sampling

Primary samples are drawn from all parts of the consignment at random, with all parts of the consignment having equal opportunity of being sampled. Simple bag sampling spear (bag trier) or bulk sampling spear for bulk grain should be used. The standard parameters used for the classification of grain that are acceptable of to be rejected are as follows; moisture content percentage- <12%, Hectolitre weight (65- 75 Kg/Hl), Insect damage (<1%), Mould damage (<1%), and Foreign matter content (<1%).

Percentage of moisture content in a given mass of grain (MC),

$$M.C = \frac{Ww - Wd}{Ww} \times 100 \qquad (8)$$

Where; W_w= weight of sample

W_d= weight of sample at 100^0C temperature in an oven for a period of 4 hours.

Equation 1 was used to calculate the percentages of foreign matters, insect damage, and mould damage in each sample analysed.

$$\text{Foreign matter \%} = \frac{\text{wt of foreign matter present in the sample}}{\text{Total wt of sample}} \text{x } 100$$

$$\text{Insect damage \%} = \frac{\text{wt of damaged grain by insect present in the sample}}{\text{Total wt of sample}} \text{x } 100$$

$$\text{Mould damage \%} = \frac{\text{wt of mould damaged grain present in the sample}}{\text{Total wt of sample}} \text{x } 100$$

$$\text{Broken grain \%} = \frac{\text{wt of broken grain present in the sample}}{\text{Total wt of sample}} \text{x } 100$$

Hectolitre Weight which is the weight of a measured volume of grain expressed in kilograms per hectolitre was measured as follows;

$$\text{Hectolitre weight} = \frac{\text{weight of grains in the cylinder}}{\text{Volume of the cylinder}} \text{x } 100$$

Weight loss due to metabolic activities- grain respiration in dry grain is extremely low and so loss in weight due to metabolic activities is very low. For example, maize at 13% moisture content stored at 23^0C temperature lost 0.0675% dry matter in 100 days. Applying this to 1,000 tonnes for 2 years, for example, the loss in weight would be 4.94 tons.

Module Three: Loading of grains into metal silo Trucks with consignments of acceptable quality grains are directed to the weighbridge for weighing. It is important that the correct quantity of grain delivered is established since weight is the basis for payment of the grain. This is accomplished by the weighing clerk carefully weighing the gross weight and the tare weight of the truck and computing the difference

RESULTS AND DISCUSSION

Analysis of grain arrival and reception with Queue theory

Analysis of goods arrival before the introduction of computer software for grain management:

Expected time per unit in the system i.e. expected time in a unit spends in the system (Eqn. 3),

$$W_s = \frac{\text{Expected number of unit in the system}}{\text{Arrival rate}} =$$

$$\frac{L_s}{\lambda} = \frac{\lambda}{(\mu-\lambda)\lambda} = \frac{1}{(\mu-\lambda)}$$

The mean arrival rate (λ) for data collected before the introduction of Computer software was 2.05. Mean service time (μ) = 1.95

Expected numbers of units in the queue Lq, using Eqn. 2

$$L_q = \left(\frac{\mu-\mu+\lambda}{\mu(\mu-\lambda)}\right) = \frac{\lambda}{\mu}.\frac{\lambda}{\mu-\lambda} \qquad L_q = 2.05 \times \frac{2.05}{0.19} = 21.54$$

Average length of non-empty queue L_n, for a non-empty queue, should be at least 2 (one being served and the other in the queue). From Eqn. 6,

$$L_n = \frac{\text{Average lenght of queue}}{\text{prob of non-empty queue}} = \frac{\frac{\lambda}{\mu}.\frac{\lambda}{\mu-\lambda}}{\left(\frac{\lambda}{\mu}\right)^2} = \frac{\mu}{\mu-\lambda}$$

= 19.5

Hence, Average waiting time in non-empty queue (expected waiting time per busy period) using Eqn.7, $W_n = \frac{1}{\mu-\lambda}$ = 10hrs

Expected waiting time per unit in the queue:

W_q= Expected time in system-time in service

$W_q = W_s - \frac{1}{\mu} = \frac{1}{\mu-\lambda} - \frac{1}{\mu} = \frac{\lambda}{\mu}.\frac{1}{\mu-\lambda}$, = 1.95 (0.1) = 10.75hrs

Analysis of goods arrival after the introduction of computer software for grain management

Following the queue formula used above,

Mean arrival time= 0.39

Mean service time= 0.918

L_q= 0.3138,

Waiting time = 1.9hrs, and average length of queue = 1.772hrs.

Assessment of Grain Facilities using Descriptive Statistics

The paired samples test was carried out on the percentage losses derived from the questionnaires administered to grain operators that were using manual management method and at the silo complex where Computer Aided Management (GSMS) was introduced. The result revealed that the probability level was 0.001.

H_0: $\theta = \theta_0$ H_1: $\theta \neq \theta_0$ for at least one θ at $\alpha = 0.05$

The null hypothesis (H_0) indicated that the manual operations denoted as θ and the computer aided management denoted as $\theta_0$are equal or the same, while the alternative hypothesis (H_1) indicated that manual operation and computer aided management are not equal. Since the probability level of 0.001 is less than the significance level 0.05, this led to the rejection of the null hypothesis. There was a significant difference between the percentage losses recorded from the software package and the manually management computed values.

Table 1. Frequency table of occurrence of samples of storage locations in Nigeria

	Location	Frequency	%	Valid %	Cumulative %
Valid	Aba	2	4.0	4.0	4.0
	Abia	1	2.0	2.0	6.0
	Abuja	3	6.0	6.0	12.0
	Akure	6	12.0	12.0	24.0
	Calabar	4	8.0	8.0	32.0
	Gombe	4	8.0	8.0	40.0
	Ibadan	6	12.0	12.0	52.0
	Ilorin	3	6.0	6.0	58.0
	Jos	2	4.0	4.0	62.0
	Kastina	4	8.0	8.0	70.0
	Kwara	3	6.0	6.0	76.0
	Lokoja	1	2.0	2.0	78.0
	Makurdi	2	4.0	4.0	82.0
	Minna	5	10.0	10.0	92.0
	Ogun	1	2.0	2.0	94.0
	Oyo	3	6.0	6.0	100.0
	Total	50	100.0	100.0	

Figures 3 to 12 was the graphical presentation of the results obtained from the questionnaire using descriptive statistics while Figure 13 shows the percentage of losses computed after the introduction of computer aided management

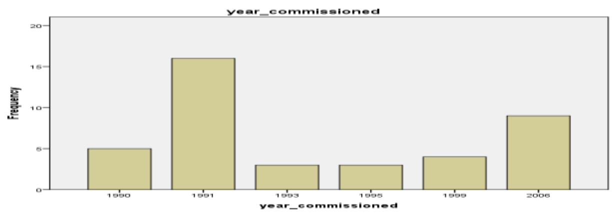

Fig. 3. Year’s operations started

Fig. 4. Occurrence of storage capacity

Figure 5. Warehouse capacity

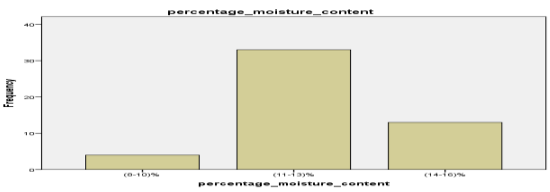

Figure 6. M.C % of sample grain

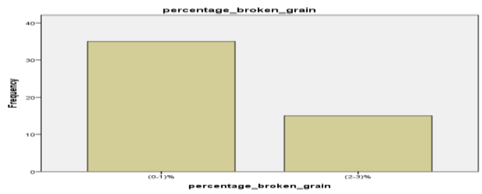

Fig. 7. Occurrence broken grain %

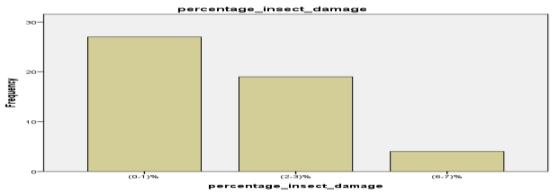

Fig. 8. Occurrence of insect damage %

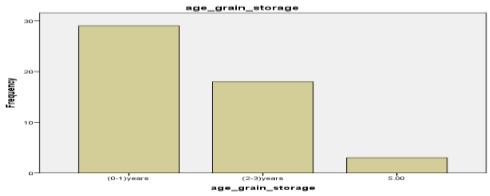

Fig. 9. Age of stored grain

Fig. 10. Losses recorded at reception

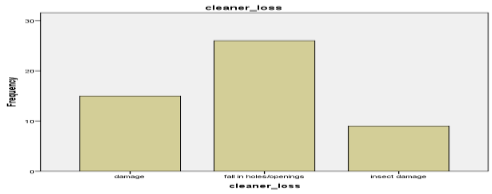

Fig. 11. Losses during the cleaning

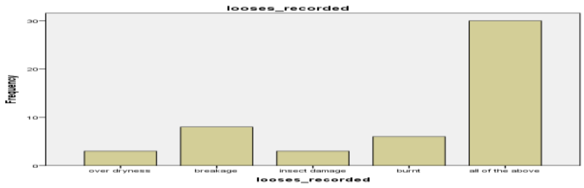

Fig. 12. Total losses during storage

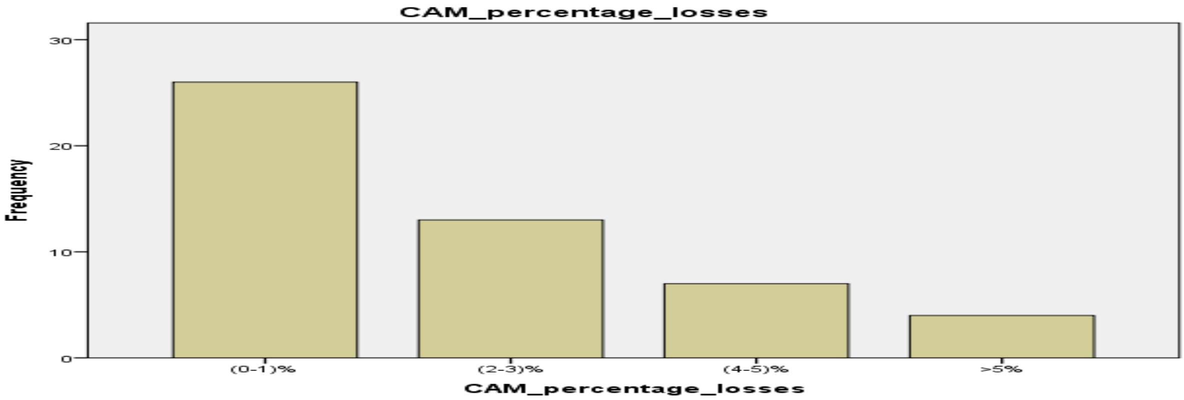

Fig. 13. Bar chart of percentage of losses computed with software

Development of Software for Grain Storage Management

The software was built to manage the day to day transactions at the silos; including the use of chemicals. It records supplies, releases and losses based on shrinkages, stock monitoring, maintenance of equipment and other events capable of reducing the stock level. All these are captured in real-time and the data centrally stored

Landing and administrative interface

The landing interface (Figure 14) was the welcome banner and the first interface that floats as soon as the package is launched. It contains basic information about the package, a few graphics that represent the general concept of silo grain management and its affiliates. Such information included; news, abstract, silo operation, products and contacts. Since our interest is mainly on silo operations, click on silo operation. While the system login of Administrative Page (Figure 15) contains the following links: ‘Add Goods’, ‘Laboratory Analysis’, ‘Silo Management’, ‘Generate Report’, ‘Admin Area’, ‘Change Password’, ‘Add Users’, and ‘Logout’.

Fig. 14. The Landing page

Fig. 15. System login page

The first step in grain management is the reception of the grain. Registration is done on first- in first – out queue system. Hence, the next interface is the good registration page (Figure 16). Goods registration log-in page contains user name login and password. Here the user is expected to log in his or her password. Only registered password will allow access to the registration page. This is very important for security reason. An intruder would be disallowed from adding or removing registration data from the list. The goods registration page (Figure 17) consists of detail information on the supplier or his/ her representative; name of supplier, address, contact number, truck registration number, type of vehicle/ capacity, name of driver, date of arrival, time of arrival, date of loading, queuing number, type of goods, quantity supplied, quality of good, name of officer on duty and rank of officer on duty. Once all these data are provided, the user should click ‘submit’. This good has been registered. This could be accessed by all users.. Figure 18 was a result sheet of goods entry interface

Fig. 16. Good Registration Login Page

Fig. 17. The Goods Registration Page

S.N	Contract No	Date	Goods	Quantity	Off cer	Report
1	1556	20:1:2013	Millet	21.44	Ajayi A. A	ACCEPTED
2	7603	20:1:2013	Maize	20.52	Ogunyanju Matthew	ACCEPTED
3	1931	20:1:2013	Maize	17.13	Ajayi A. A	ACCEPTED
4	2787	21:1:2013	Maize	31.09	Ogunyanju Matthew	ACCEPTED
5	2141	1:2:2013	Maize	21.44	Ogunyanju M	ACCEPTED
6	1965	20:1:2013	Maize	21.44	Ajayi A. A	ACCEPTED
7	1189	4:2:2013	Maize	30.02	Ogunyanju M	ACCEPTED
8	1266	5:2:2013	Maize	24.03	Ogunyanju Matthew	ACCEPTED
9	1395	20:1:2013	Maize	30	Ajayi A. A	REJECTED
10	9841	1:2:2013	Maize	30	Ajayi A. A	REJECTED

Fig. 18. Goods entry page

Grain sampling, analysis and goods laboratory status page

This is the module for sampling of goods supplied, analyse and determine grains to accept and reject before they are allowed to enter or leave the storage location**.** The interfaces were designed in a way that once the data are entered, it cannot be changed. The laboratory officer has his own password. He is expected to load the results of the analysis as they are being carryout. The interface is designed in a way that, once the data is entered, it cannot be changed except with the knowledge of the coordinating headquarter. The reason for the change must be made bare to the authority at the head office. The laboratory login page (Figure 19) consists of the username and password. This page is created for the laboratory officer, his/ her representative and/ or the manager. It opens to the laboratory test page (Figure 20). Each laboratory test page assigns contract number to every consignment. This is done automatically in order to avoid any falsification of information. The laboratory parameters are moisture content (%), foreign matter content (%), Hectolitre Weight (kg/hl), Colouration, Endosperm status, Insect damage (%), Mould (%) and broken grain content (%). Table 2 shows the List of registered goods and corresponding laboratory results computed from software

Fig. 19. Laboratory login page

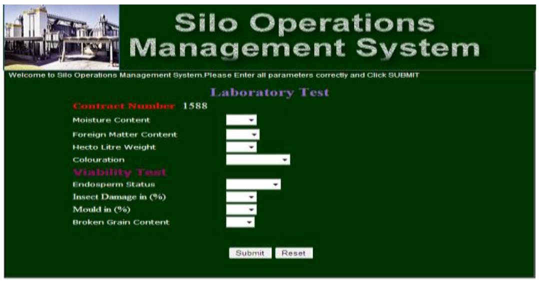

Fig. 20. Laboratory test page

Silo Operations Management System

S.N	Good No	Moisture Content	Foreign Matter	Hecto Litre	Colouration	Edosperm Status	BGC
1	3767	Accept	Accept	Accept	Accept	Accept	Accept
2	1823	Accept	Accept	Accept	Accept	Accept	Accept
3	8183	Reject	Reject	Reject	Accept	Accept	Accept
4	3202	Accept	Accept	Reject	Accept	Accept	Accept
5	9876	Accept	Accept	Reject	Accept	Accept	Accept
6	1186	Accept	Accept	Accept	Accept	Accept	Accept
7	7722	Reject	Accept	Reject	Accept	Accept	Accept
8	1499	Reject	Accept	Reject	Accept	Accept	Accept
9	1254	Accept	Reject	Reject	Reject	Reject	Accept
10	2847	Accept	Accept	Accept	Accept	Accept	Accept
11	1335	Reject	Accept	Reject	Accept	Accept	Accept
12	8653	Accept	Accept	Accept	Accept	Accept	Accept
13	1986	Accept	Accept	Accept	Accept	Accept	Accept
14	1182	Accept	Reject	Reject	Accept	Accept	Accept
15	1445	Accept	Accept	Accept	Accept	Accept	Accept
16	1037	Accept	Accept	Reject	Accept	Accept	Accept
17	9126	Accept	Accept	Accept	Accept	Accept	Reject
18	2102	Accept	Accept	Accept	Accept	Accept	Accept
19	1961	Accept	Accept	Reject	Accept	Accept	Accept

Silo Operations Management System

REGISTER GOODS

S.N	ContractNo	Date	Vehicle	Driver	Truck Reg	Goods	Quantity	Officer	Report
1	1556	20:1:2013	Truck	Gbenga	XA697KST	Millet	21.44	Ajayi A. A	ACCEPTED
2	7603	20:1:2013	Truck	akeem	GBY75XA	Maize	20.52	Ogunyanju Matthew	ACCEPTED
3	1931	20:1:2013	911	Sunday	XH783ABC	Maize	17.13	Ajayi A. A	ACCEPTED
4	2787	21:1:2013	Truck	Isak Gniya	XG736MNA	Maize	31.09	Ogunyanju Matthew	ACCEPTED
5	2141	1:2:2013	911	Abbass	BDG131XA	Maize	21.44	Ogunyanju M	ACCEPTED
6	1965	20:1:2013	Truck	Gbenga	XA697KST	Maize	21.44	Ajayi A. A	ACCEPTED
7	1189	4:2:2013	Truck	Umaru	XF 937 MKA	Maize	30.02	Ogunyanju M	ACCEPTED
8	1266	5:2:2013	Truck	Rafiu	WSN83XA	Maize	24.03	Ogunyanju Matthew	ACCEPTED
9	1395	20:1:2013	Truck	Garba	XA582KTA	Maize	30	Ajayi A. A	REJECTED
10	9841	1:2:2013	Truck	mohd	XEI53DKA	Maize	30	Ajayi A. A	REJECTED

Figures 21 to 24 show the computed laboratory results and goods status for two different consignments supplied by Duo- Team and Co Ltd with the software developed.

Fig. 21. Laboratory result for Duo-Team

Fig. 22. Goods status page for Duo-Team

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Figure 23. Laboratory results for Duo-Team

Figure 24. Good status for Duo- Team

Module for Weighing

The weighing page contains the following field; Contract Number, Entry Weight, Exit Weight, Net Weight. The following also can be viewed as a report for the list of Registered Goods; the serial Number, Good's Name, Store Number, status, update. To enter weigh in or weigh out records, click "edit weight" against the contract ID number generated automatically by the software. Enter the weigh in or out as the case may be. The record will cease to be editable when both weigh in & out records have been entered. You can always go back to list page .Figures 25 and 26 show the weight entry page, and store issue voucher respectively.

Figure 25 Weighing Page

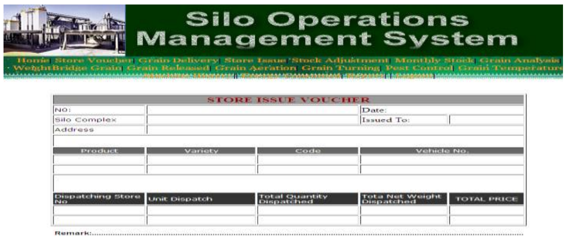

Figure 26. Stored issue voucher

Silo monitoring page

Silo monitoring page (Figure 27) consists of the following links: weighing, silo management, stock management, temperature reading and logout. The following can also be viewed; the serial number, the good name and the silo number. Here the user or reporting officer will assign specific number to every available silo in the complex and the grain to be stored in the silo would be selected before been submitted. This page will enable the user to know the number of silo that each consignment was kept. It is impossible to transfer different grain into the same silo bin. Figure 28 is the stock management page.

Figure 27. Silo Monitoring Page

Figure 28. Stock management login page

Report generation

During entry of data on the software page, click on 'generate report' to generate report for suppliers as evidence of the condition of the grain he supplied. The details of the supplier and his goods are displayed here. If the good is rejected, the supplier may want to know why his or her good was rejected then the officer will click on REJECTED and the page is displayed which will show details. This report could be printed by clicking 'print'. The 'generate report' page takes care of; laboratory result, monthly grain analysis, store receiving voucher (weight) and release voucher. In order to have an accurate quantity of grains available in each of the silo cells, the program developed could compute an estimated quantity left after the necessary deductions. On a monthly base, a calculated quantity could be made. The major factors that contribute to storage loss as discovered included, the moisture content, insect damage, mould damage, broken grain content (BGC) which influence the building up of dust (Figure 29).

The storage management of grain stock

The storage management page (Figure 30) consists of the following items; silo number, type of grain, name of officer, and month of the year. The Silo number will be selected by the user and the date of the year will be entered to ensure, proper monitoring. If it is found that any silo shows increase in the temperature of 0.5^{0}C, or abnormal spot increment, aeration should be done. Aeration is introduced into silo construction for the purpose of temperature management, to control mould proliferation, insect and moisture migration. Grain is often aerated with ambient air by means of simple fans in tropical countries [20]. Temperature reading daily will expose timely any deterioration spots and grain condition at various levels within the bin. Table 4 is the monthly temperature readings monitored with software

Figure 30: Storage management page

Fig. 29: The Report page

Table 4. Monthly temperature readings monitored with software

Silo Number	0003	Month of the Year	Jun
External Temp	37	Humidity	42.00

S.N	T1	T2	T3	T4	T5	Average
1	39.50	39.50	39.60	38.85	40.00	39.49
3	40.10	40.30	40.00	41.30	40.50	40.44
5	36.55	37.00	38.00	45.00	37.45	38.80
7	40.10	40.30	40.00	41.30	40.50	40.44
P1	Aerate	Aerate	Aerate	Aerate	Aerate	Normal
8	40.45	42.00	41.95	41.35	42.00	41.55
P2	Aerate	Aerate	Aerate	Aerate	Aerate	Normal
9	40.00	40.35	41.45	41.65	41.95	41.08
P3	Aerate	Aerate	Aerate	Aerate	Aerate	Normal
10	40.45	41.25	40.65	41.35	41.85	41.11
P4	Aerate	Aerate	Aerate	Aerate	Aerate	Normal
11	42.00	41.95	42.00	41.20	42.00	41.83
P5	Aerate	Aerate	Aerate	Aerate	Aerate	Normal
12	41.95	41.45	41.35	41.20	41.95	41.58
P6	Aerate	Aerate	Aerate	Aerate	Aerate	Normal
13	41.55	42.00	41.80	41.00	41,65	41.47
P7	Aerate	Aerate	Aerate	Aerate	Aerate	Normal
14	41.90	41.80	41.75	41.20	41.45	41.62
P8	Aerate	Aerate	Aerate	Aerate	Aerate	Normal
15	42.00	41.45	41.35	42.00	40.40	41.44
P9	Aerate	Aerate	Aerate	0	Aerate	Normal
16	40.35	40.65	41,00	41.00	41.95	40.99
P10	Aerate	Aerate	0	0	0	Normal
P1	Aerate	Aerate	Aerate	Aerate	Aerate	Aerate
17	40.45	42.00	41.95	41.35	42.00	41.55
P2	Aerate	Aerate	Aerate	Aerate	Aerate	Aerate
18	40.00	40.35	41.45	41.65	41.95	41.08
P3	Aerate	Aerate	Aerate	Aerate	Aerate	Aerate
19	40.45	41.25	40.65	41.35	41.85	41.11
P4	Aerate	Aerate	Aerate	Aerate	Aerate	Aerate
20	42.00	41.95	42.00	41.20	42.00	41.83
P5	Aerate	Aerate	Aerate	Aerate	Aerate	Aerate
21	41.95	41.45	41.35	41.20	41.95	41.58
P6	Aerate	Aerate	Aerate	Aerate	Aerate	Aerate
22	41.55	42.00	41.80	41.00	41,65	41.47
P7	Aerate	Aerate	Aerate	Aerate	Aerate	Aerate
23	41.90	41.80	41.75	41.20	41.45	41.62
P8	Aerate	Aerate	Aerate	Aerate	Aerate	Aerate
24	42.00	41.45	41.35	42.00	40.40	41.44
P9	Aerate	Aerate	Aerate	0	Aerate	Aerate
25	40.35	40.65	41,00	41.00	41.95	40.99
P10	Aerate	Aerate	0	0	0	Aerate

Monthly grain monitoring report

Monthly report page display the status of grain stored in a particular silo, such as moisture content, insect damage, mould, broken grain content, and mould percentage loss. Growth of insects, mites, moulds and other microbes are at their highest levels in the 68^0 to 95^0F range. Hence to prevent insect movement, temperatures should be lower than 45^0F and to prevent insect multiplication temperature should be lower than 59^0F.

The stock adjustment form page allows regular updating of stock; this is necessitated as a result of insect infestation, shrinkage, moulding, theft, possibility of weight loss. The manager at the station or desk officer at the headquarters is allowed to adjust the total grain stock but approver must be taking. The temperature reading of a given silo is taking every day. The silo number are selected by the user and the date of the year will be entered to ensure proper monitoring. The plant operator must daily read and record the temperatures on this page for interpretation by the manager in charge. If it is found that any silo shows increase in the temperature of 0.5^0C or abnormal spot increment, aeration should be done. Temperature reading daily will expose any deterioration spots and general grain condition at various levels within the bin. This is one of the cardinal ways to monitor grain in storage. Figures 31 to 36 show the monthly grain monitoring procedures; report update, stock adjustment, stock and grain turning register respectively.

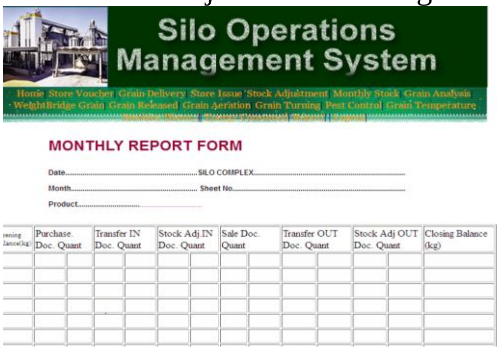

Fig. 31. Monthly report update page

Fig. 32. Monthly stock adjustment page

Fig. 33.Monthly stock management page

Fig. 34. Grain turning (recycling) page

Storage equipment maintenance

Interfaces were developed for all the installed silo equipment. This is necessary in order to monitor the maintenance of the machines. Machines history card page is created for regular updating of the conditions of the installed machines; servicing time and other maintenance activities. Figures 35 and 36 show the interface developed for the monitoring of all installed equipment. This would enhance their good conditions and prompt management.

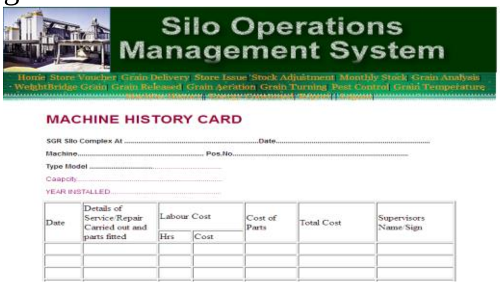

Fig. 35. Machine history card

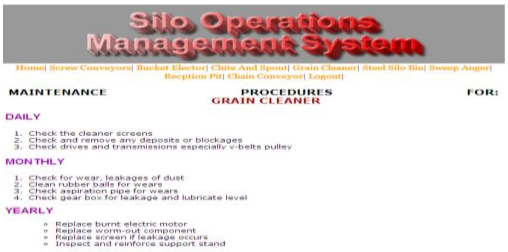

Fig. 36. Grain cleaner page

CONCLUSION

The introduction of computer applications for the monitoring and management aids for the entire process of grain handling and storage management is economically justifiable base on many reasons.. There would not be any need to be travelling from one location to the Headquarter or another station. This is because the application is web based; it can be exported to PDF, Word, and Excel (all downloadable). The data already entered is safe and accurate. There is security and access control. Search allows for record querying based on user chosen parameter, records can be printed at the storage location, any of the other branches, and even at the Headquarter concurrently.

The laboratory officer would not need to report to the manager before his work could be accessed through the web. With the introduction of computer-aided grain management system, the colossal loss recorded yearly during grain reception and releasing exercise at the Federal Government of Nigeria, grain reserve program would be curtailed. The results obtained from the software indicate a very wide margin of advantages over the error- prone manual recording of data. This work had indicated how avoidable losses that have characterised the grain storage industry especially in Nigeria could be overcome.

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