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# Nutritional Qualities of Gari Stored in Specialised Warehouse of the Strategic Grain Reserve Silo Complex Minna, Nigeria

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***Abstract*—The nutritional qualities of gari properly packaged in double layer polypropylene bags stacked in layers on pallets in the specialized warehouse of the strategic grain reserve (SGR) silo complex Minna was investigated. The main objectives of this work is to evaluate the nutritional quality attributes of gari stored in the specialised warehouse to ensure safety and general acceptability of gari released to Nigerian market in time of famine and Natural disaster under the directive of the Federal government. The initial quality attributes of the fresh consignment of gari for storage in specialized warehouse were determined using AOAC standard method. The nutritional quality attributes were determined on monthly basis at three replicates for twelve months. A randomized block design of 7 (Quality attributes) × 12 (Storage duration) × 3 (replicates) making a total of 252 samples used for the experiment. Data collected were analyzed using SPSS (20.0) statistical package and means were separated. The results shows that the sample had an initial moisture content of 11.04 ± 0.01%, crude protein of 0.84 ± 0.00%, crude fat 1.93 ± 0.15%, crude fibre 1.00 ± 0.06%, crude ash 1.99 ± 0.01%, carbohydrate content 75.12 ± 0.01%, hydrogen cyanide content 1.32 ± 0.01mg/g, pH of 4.80 ± 0.00 and total solid content 88.96 ± 0.01%. The storage of gari in the specialised warehouse did not significantly affect ($p<0.05$) moisture content, crude fat, carbohydrate content, and total solid content after 12 months of storage, while the crude fibre content and ash content were significantly affected. However, the quality attributes of the gari samples after 12 months of storage were still within the FAO/WHO and SON recommended standard for gari, hence fit for human consumption. It is therefore concluded that packaging of gari in double layer polypropylene bags stacked on pallets in specialised warehouse of SGR silo complex Minna is effective for gari storage and protection against deterioration. This method of storage is therefore recommended for use over the conventional method of gari packaging and storage in the warehouse.**

***Keywords*— Nutritional qualities, Gari, Specialized warehouse, double layer polypropylene bag***

## I. INTRODUCTION

Gari is the most popular form of cassava products consumed by several millions of people in the African continent especially in the West African sub – region. Gari is a granulated white or yellowish product with 10 – 15% moisture content that permits a long conservation in normal atmospheric conditions [1].

Unit operations involved in gari production include peeling of cassava root, washing, and grating, followed by pressing / dewatering and fermentation, pulverizing and frying [3]. The nutritional properties of gari include the carbohydrate, total solid content, energy value, ash, fibre, protein, moisture, pH value and cyanide contents among others while the physical properties include colour, particle size, density and organoleptic properties. Gari consist of 81.8% carbohydrate, 1.4% crude fibre and 0.9% crude protein content [2]. The popularity of gari is based probably on the fact that the granules are precooked, thus, a very short time is needed to prepare them as main dishes or snacks [4].

However, during each unit operation of gari processing, processors have little or no quality control of the finished product, which may result in the product having higher moisture content than recommended, thereby making it unsuitable for long - term storage. Moisture content of gari is a very important parameter to be considered during drying operation to increase the shelf life of the product. Enforcing quality measures is difficult task due to the large number of processors and the relatively small output of each one. The variation in the quality of products in the same market can be tremendous and adulteration of cassava product is common as revealed by Food and Agricultural Organization [5].

The Federal Government of Nigeria introduced gari storage into its Strategic Grain Reserve (SGR) stock in 2003 after the launch of presidential initiative on cassava in 2002. This is with a view to absorb the glut of gari in the market and

ensure competitive price for cassava farmers as well as gari processors thereby guaranteeing return on their investments.

Gari are usually procured from accredited government processors under Licensed Buying Agents (LBA) and stored in Strategic Grain Reserve Specialized warehouses across the nation Nigeria. The Federal Government in 2012 procured a total quantity of 619 Metric Tonnes (MT) with a reception parameters of moisture content 8 - 10%, cyanide content 8 - 10%, pH 4 - 8, whitish in colour, particle size 0.1 - 1.0mm, odourless, free from contaminations (sand, black specks, insects, fibre) fit for storage into the Specialised warehouses in Strategic Food Reserve silo complex in Minna, Niger State. The gari stored are usually released to the public through a presidential directive during emergencies such as flood, civil unrest, war, food scarcity or high cost of food in the market.

FAO [6] data analysis revealed that spoilage of gari occurs in the store due to inadequate dryness along the production unit which results to growth of microorganisms. Environmental impact including temperature and relative humidity are other factors that affect gari granules in the store if not in moderate and acceptable limits. Improper storage factors including the ventilation allowance, pallets setup, improper packaging and bulk arrangement of the stored product tend to enhance deterioration of stored gari [7].

Research has shown that several plastics and films adoptable for gari and sugar (dry products) packaging which includes regenerated cellulose (cellophane), cellulose acetate, polymid (nylon), rubber-hydrochloride (pliofilm), polyester resin, polyethylene resin, polypropylene resin, polystyrene resin, polyvinlidene chloride, polyvinylchloride, hessian bags, transparent plastic polyethylene bags. However, Polyethylene bag is considered to be commonly used as a gari packaging material due to its good mechanical properties and low cost [8]. Gari has a calorific value of 334 - 360 kJ per 100g serving and is a low protein food of about 0.9%. The nutritional and physical properties of gari is a function of the cassava variety, age of cassava, time of harvesting, processing methods, packaging methods, storage conditions and duration of storage. However, an improper storage method causes deterioration on the product during on long time storage [9].

Modern storage method (specialised warehouses (Plate 1 and 2) has been developed by Nigerian government to control gari deterioration and maintain quality of gari released to Nigerian market for sale and human consumption. However, in strategic grain reserve (SGR) warehouse storage method, the storage and release of gari product requires timely evaluation after the initial reception consideration of the physical, nutritional and microbiological quality attributes on the product prior to release.

Thus, the risk of releasing low quality or even contaminated gari to the public is very high.

The objectives of this study is to evaluate the effect of storage conditions and duration on the nutritional qualities of gari stored in the specialized warehouse of the strategic grain reserve silo complex Minna for twelve (12) months period of time prior to release. This is to ascertain the safety and quality of the gari release to Nigerian market for human consumption after twelve months of storage.

Plate 1: Interior View of Specialised Warehouse for Storage of Gari and other Agricultural Produce in SGR Silo Complex Minna, Nigeria

Plate 2: Exterior View of Specialised Warehouse for Storage of Gari and other Agricultural Produce in SGR Silo Complex Minna, Nigeria.

## II. MATERIALS AND METHODS

Freshly prepared gari sample fit for storage in the Strategic Grain Reserve warehouse Minna was procured from accredited gari processors under the licenced buying agent scheme, which was assessed and used for the study. All the reagents used for the laboratory analyses were of analytical grade and most of the equipment used for the analyses are sophisticated and automated. Some of the reagents used include Acetone, 1.2 % $H_2SO_4$ solution (Tetraoxosulphate (VI) acid), 1.25% NaOH solution (sodium hydroxide solution), selenium catalyst, Petroleum ether 60 – $80^0$C, Copper catalyst, 40% NaOH solution (used for protein digestion and steam distillation), 0.1 g of Methyl red indicator ($C_{15}H_{15}N_3O_2$), 0.1 g of Bromocresol green indicator ($C_{21}H_{14}Br_4O_5S$), 4% Boric acid ($H_3BO_3$), Receiver solution, 0.1 N HCl and Distilled water amongst others. However, AOAC laboratory scheme was systematically followed for laboratory test.

## III. EXPERIMENTAL PROCEDURE

The Nutritional quality attributes of gari samples were assessed at reception as described in Nigerian industrial standard for gari storage in warehouse by Standard Organization of Nigeria [10]. The first experimental samples (sp1) were randomly selected from batch A. The initial quality attributes of the fresh consignment of gari for storage in specialised warehouse were determined using standard methods as described by Association of Official Analytical Chemists (AOAC) [10]. Samples were packaged in double layer polypropylene bags and stacked in layers on pallets in the warehouse.

The temperature and relative humidity of the specialised warehouse were determined on 6 hourly basis for the period of 12 months (Table 1). The nutritional quality attributes were determined on monthly basis at three replicates for twelve months. A randomized block design of 9 (Quality attributes) × 12 (Storage duration) × 3 (replicates) making a total of 324 samples was used for the experiment.

The nutritional parameters evaluated were determined as prescribed by Association of Official Analytical Chemists [10], about 1g of each sample was carefully weighed on an electrical analytical balance (Adventurer OHAUS by MELLER, Switzerland; Type PM 2000, Serial No: H52764 and sensitivity ± 0.001g). The weighed samples were digested using Micro-Kjeldahl nitrogen digestion and distillation apparatus (Gerhardt Bonn Kjeldatherm, Germany; Type TR) for crude protein determination.

## IV. STATISTICAL ANALYSIS

Data collected were statistically analyzed using SPSS 20.0 statistical package. A one-way analysis of variance (ANOVA) was carried out to determine significant differences and means were separated using Duncan Multiple Range Test (DMRT).

## V. RESULTS AND DISCUSSIONS

The initial quality attributes of gari sample evaluated at reception before storage are 11.04 ± 0.01% moisture contents, 0.84 ± 0.00% crude protein content, 1.93 ± 0.15% crude fat content, 1.00 ± 0.06% crude fibre contents, 1.99 ± 0.01% ash content, 75.12 ± 0.01% carbohydrate content and 88.96 ± 0.01% total solid content.

The moisture content of the samples used for this study was lower than the 12% maximum value recommended by FAO for gari but significantly higher than the prescribed range of 8 – 10% recommended by Standard Organization of Nigeria (SON). This variation in moisture content could probably be as a result of the processing step followed by the producers especially in tempering after frying.

The initial 1.99 ± 0.01% ash and 1.00 ± 0.06% crude fibres content were significantly lower than the recommended 2.72% and 2.00% recommended by SON respectively. This variation could be as a result of varietal differences in the root tubers and the processing steps used for the gari production.

The initial protein and carbohydrate content of the sample used for this study were within the range which reported a protein and carbohydrate content range between 0.87 – 1.37% and 77.90 – 84.50% respectively [11]. But significantly higher than 74% carbohydrate content reported by [12].

## VI. NUTRITIONAL QUALITY ATTRIBUTES OF GARI STORED IN WAREHOUSE OF THE SGR SILO COMPLEX MINNA

Statistical analysis shows significant variations in the environmental storage conditions (table 1) and nutritional properties of gari during the storage period. The mean of nutritional quality attributes of gari stored in sgr warehouse between july, 2012 and june, 2013 evaluated on monthly basis are presented in table 2.

Table 1: Environmental Conditions of the Warehouse in the Strategic Grain Reserve (SGR) Silo Complex Minna

| S/N | Month / Year of Sample collection | Temperature ($^{O}$C) | Relative Humidity (%) |
|---|---|---|---|
| 1. | July, 2012 | $30.79\pm0.20^{f}$ | $67.00 \pm 0.00^{c}$ |
| 2. | August, 2012 | $30.50\pm0.00^{c}$ | $78.00 \pm 0.00^{j}$ |
| 3. | September, 2012 | $27.50\pm0.00^{a}$ | $72.00 \pm 0.00^{g}$ |
| 4. | October, 2012 | $30.90\pm0.00^{d}$ | $67.00 \pm 0.00^{c}$ |
| 5. | November, 2012 | $32.00\pm0.00^{f}$ | $64.00 \pm 0.00^{b}$ |
| 6. | December, 2012 | $31.40\pm0.00^{e}$ | $63.00 \pm 0.00^{a}$ |
| 7. | January, 2013 | $29.50\pm0.29^{b}$ | $69.88 \pm 0.12^{d}$ |
| 8. | February, 2013 | $32.96\pm0.03^{g}$ | $70.00 \pm 0.01^{e}$ |
| 9. | March, 2013 | $34.54\pm0.02^{h}$ | $71.02 \pm 0.02^{f}$ |
| 10. | April, 2013 | $32.96\pm0.03^{g}$ | $64.18 \pm 0.16^{b}$ |
| 11. | May, 2013 | $36.49\pm0.26^{j}$ | $75.02 \pm 0.03^{i}$ |
| 12. | June, 2013 | $35.65\pm0.03^{i}$ | $73.09 \pm 0.07^{h}$ |

∗Values are means of triplicate determinations ± Standard error (Mean ± SEM)
∗Means followed by the same superscript in each column are not significantly different at P<0.05 as assessed by LSD, Tukey and Duncan's Multiple Range Test (DMRT).

### *A. Moisture Contents*

Statistical analysis shows that there was significant decrease in the moisture contents of gari stored in SGR specialised warehouse (Figure 1). The highest moisture content of 13.78 ± 0.01% was observed in November, 2012 while the least value of 9.61 ± 0.01% was noted in February, 2013. The reasons for the observed variations in the moisture content could be as a result of changes in the atmospheric wealther conditions (change in temperature and relative humidity Table 1).

However, the initial moisture content of 11.04 ± 0.01% and 10.10 ± 0.01% at the end of twelve months of storage were within the 12% recommended range for gari storage by World Health Organization standard [13]. This implies that the gari granules at the inception is fit for storage as low moisture content would tend to increase the shelf life of the product thereby reduce the growth of microorganisms responsible for the spoilage of food.

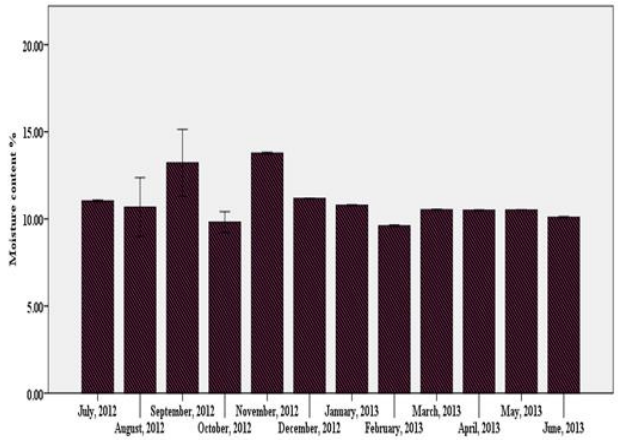


Figure 1: Error Bar for Moisture Contents Value of Gari Stored in Minna SGR Silo Complex Specialised Warehouse between July, 2012 – June, 2013.

### B. *Crude Protein Contents*

Statistical analysis also indicate that there were significant differences (P<0.05) in the crude protein contents of the stored gari granules between July, 2012 and June, 2013. Nutritionally, protein is an essential components required by the human body. However, the percent protein contents obtained in this study ranged between 0.74 ± 0.01% in November, 2012 (lowest) and 1.88 ± 0.01% in May, 2013 (highest). However, these variations could be as a result of the adequate processing method used, packaging style and favouarble conditions of the specialised warehouse. The variations in the protein content during storage are as presented in Figure 2. The protein content of 1.88 ± 0.01% obtained in the month of May, 2013 was observed to be higher than the 1.30% and 1.12% reported [4,13]. This is an indication that storability has no deteriorative effect on the protein contents of gari stored in SGR Minna silo complex. Therefore, this could be used in the formulation of protein-rich food preparations where maximum solubility of protein is desired.

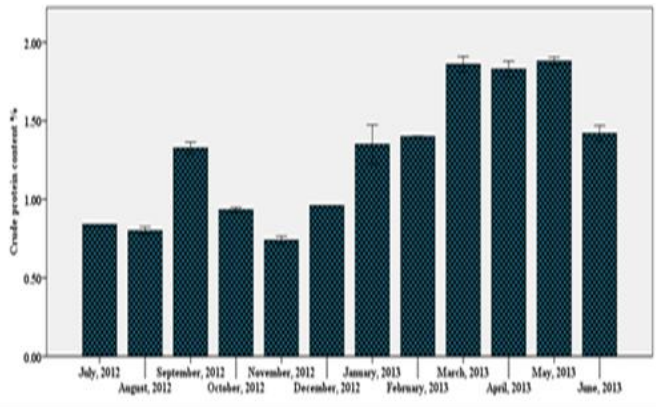


Figure 2: Error Bar Crude Protein Content Value of Gari Stored in Minna SGR Silo Complex Specialised Warehouse between July, 2012 – June, 2013

The results shows that there were no significant difference in the value obtained for crude protein contents of 1.40 ± 0.00% in the months of February, 2013 and 1.42 ± 0.01% in June, (2013), but there were significant differences (P > 0.05) in the observed values of 1.35 ± 0.03%, 1.86 ± 0.01% and 1.83 ± 0.01% obtained in January 2013, March, 2013 and April, 2013 respectively (Table 2). The protein content variations all through the storage period were also higher than 0.9% crude protein content previously reported [2].

### C. *Crude Fat Contents*

The crude fat content obtained in this study (Table 2) for the stored gari in SGR warehouse shows significant decrease (P<0.05) within the period of storage. This is applicable over certain period of time within the twelve months of gari storage. The highest value for crude fat content of stored gari in SGR was 3.00 ± 0.06% obtained in the month of March, 2013 while the lowest value of 1.02 ± 0.08% was obtained in the month of December, 2012. The results of this study was higher than 1.40% and 2.3% crude fat content values prescribed by Food and Agricultural Organization.

### D. *Crude Fibre Contents*

The result shows that the crude fibre contents of the stored gari sample increased significantly with increase in storage period. The crude fibre content ranged between 1.00 ± 0.06% to 4.00 ± 0.29% (Table 2).

The initial crude fibre content of the sample and at the end of the twelve months of storage period were significantly higher than the recommended values of 0.9%, 2.0% and 2.0% as reported by FAO, WHO and SON respectively. The high fibre content of food will help the consumer to be healthier by keeping the bowels working and moving other foods quickly through the body.

The highest value of crude fibre content was 4.00 ± 0.29% observed in November, 2012 while lowest crude fibre contents was 1.00 ± 0.06% observed in July, 2012, April and May, 2013.

Statistically, there were significant differences (P<0.05) in the results of the analyses for the sample taken across the months. The trend of the results were in agreement with previous report [4] but higher than that of FAO. This variation in crude fibre content could be probably due to the varietal differences in the cassava root tuber used for the gari production.

### E. *Crude Ash Contents*

The mean ash content of stored gari product used for this study shows significant differences (P<0.05) in the values obtained throughout the storage period except for the months of December, 2012, January, 2013 and June, 2013 respectively. However, it was observed that crude ash content of 5.00 ± 0.06% obtained in October, 2012 has the highest value while the lowest crude ash content 1.00 ± 0.00% was observed in December, 2012. The crude ash content at the end of the twelve month of storage were within the recommended standard by World Health Organization [13], Standard Organization of Nigeria [8] and Food and Agricultural Organization [5].

### *F. Carbohydrate Content*

The result of carbohydrate content in this study ranged between 75.12 ± 0.01% (lowest) and 84.28 ± 0.00% (highest) The highest carbohydrate content was observed in the last month of the experiment in June, 2013 while the lowest carbohydrate contents was recorded in the first month of sampling in July, 2012. Significant increase pattern in the carbohydrate content of gari stored in the warehouse of SGR silo complex are presented in Figure 3. The carbohydrate content at the end of the twelve months of storage is however within the expected range by FAO [15].

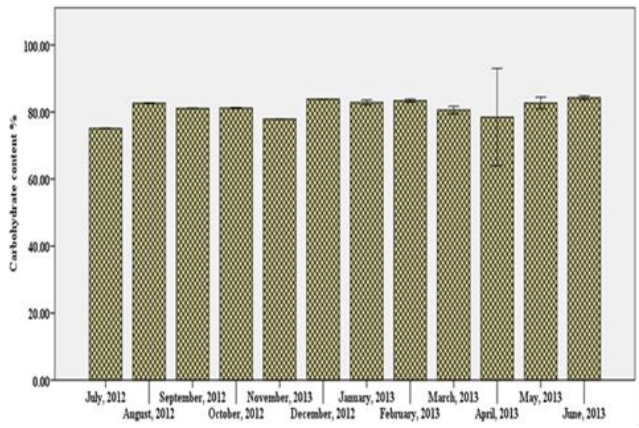


Figure 3: Error Bar Carbohydrate Content Value of Gari Stored in Minna SGR Silo Complex Specialised Warehouse between July, 2012 – June, 2013

### *G. Total Soluble Contents*

The mean of total soluble content of the stored gari samples as obtained throughout the duration of the experiment ranged from 86.22 ± 0.01% (minimum value) in November, 2012 to 90.70 ± 0.18% (maximum value) in February, 2013 (Table 2). The solids concentration of a sucrose containing solution is widely used during fruit and vegetable processing to determine the concentration of sugar in the products. Sugar concentration is expressed in degrees Brix. At 20°C, the Brix is usually considered equivalent to the percentage of sucrose (sugar) in the solution (60° Brix is equivalent to a sugar content of 60%).

## VII. CONCLUSIONS

Gari quality attributes has been ascertained for effective safe storage and protection against deterioration in the SGR warehouse when properly packaged in doubled layer polypropylene bags and stacked on wooden pallets. Therefore, specialised warehouse is an efficient storage structure for safe storage of gari granules, which indicates that gari under this storage condition is nutritionally safe and acceptable for consumption when stored up to twelve months in the specialised warehouse of the strategic grain reserve silo complex, Minna, Nigeria.

Table 2: Nutritional Qualities of Gari Stored in Warehouse of the Strategic Grain Reserve (SGR) Minna Silo Complex Minna

| Month/Year | MC (%) | CP (%) | FC (%) | CF (%) | Ash (%) | CHO (%) | TS (%) |
|---|---|---|---|---|---|---|---|
| July, 2012 | $11.04 \pm 0.01^{cd}$ | $0.84 \pm 0.00^{c}$ | $1.93 \pm 0.15^{cd}$ | $1.00 \pm 0.06^{a}$ | $1.99 \pm 0.01^{d}$ | $75.12 \pm 0.01^{a}$ | $88.96 \pm 0.01^{bc}$ |
| August, 2012 | $10.68 \pm 0.39^{cd}$ | $0.80 \pm 0.01^{b}$ | $1.97 \pm 0.09^{cd}$ | $2.50 \pm 0.01^{c}$ | $3.38 \pm 0.00^{e}$ | $82.64 \pm 0.00^{ab}$ | $89.32 \pm 0.39^{bcd}$ |
| September, 2012 | $13.22 \pm 0.44^{e}$ | $1.33 \pm 0.01^{e}$ | $1.77 \pm 0.07^{c}$ | $2.00 \pm 0.06^{b}$ | $1.38 \pm 0.00^{bc}$ | $81.10 \pm 0.01^{cde}$ | $86.78 \pm 0.44^{a}$ |
| October, 2012 | $9.82 \pm 0.14^{a}$ | $0.93 \pm 0.00^{e}$ | $1.32 \pm 0.10^{b}$ | $3.00 \pm 0.00^{b}$ | $5.00 \pm 0.06^{f}$ | $81.21 \pm 0.00^{cde}$ | $90.18 \pm 0.14^{ef}$ |
| November, 2012 | $13.78 \pm 0.01^{f}$ | $0.74 \pm 0.01^{a}$ | $1.13 \pm 0.10^{ab}$ | $4.00 \pm 0.29^{e}$ | $3.50 \pm 0.06^{e}$ | $77.71 \pm 0.01^{ab}$ | $86.22 \pm 0.01^{a}$ |
| December, 2012 | $11.18 \pm 0.00^{d}$ | $0.96 \pm 0.00^{e}$ | $1.02 \pm 0.08^{a}$ | $3.00 \pm 0.00^{d}$ | $1.00 \pm 0.00^{a}$ | $83.86 \pm 0.00^{de}$ | $88.82 \pm 0.00^{b}$ |
| January, 2013 | $10.79 \pm 0.01^{cd}$ | $1.35 \pm 0.03^{e}$ | $2.00 \pm 0.06^{cd}$ | $2.00 \pm 0.00^{b}$ | $1.00 \pm 0.10^{a}$ | $82.86 \pm 0.18^{de}$ | $89.17 \pm 0.89^{bcd}$ |
| February, 2013 | $9.61 \pm 0.01^{a}$ | $1.40 \pm 0.00^{f}$ | $2.60 \pm 0.12^{g}$ | $1.00 \pm 0.12^{a}$ | $2.00 \pm 0.12^{d}$ | $83.39 \pm 0.10^{de}$ | $90.70 \pm 0.18^{f}$ |
| March, 2013 | $10.53 \pm 0.00^{bc}$ | $1.86 \pm 0.01^{gh}$ | $3.00 \pm 0.06^{h}$ | $2.00 \pm 0.12^{d}$ | $2.00 \pm 0.15^{d}$ | $80.61 \pm 0.26^{bcd}$ | $89.71 \pm 0.14^{de}$ |
| April, 2013 | $10.50 \pm 0.01^{bc}$ | $1.83 \pm 0.01^{g}$ | $2.50 \pm 0.12^{fg}$ | $1.00 \pm 0.06^{a}$ | $1.60 \pm 0.15^{c}$ | $78.47 \pm 3.38^{bc}$ | $89.10 \pm 0.21^{de}$ |
| May, 2013 | $10.52 \pm 0.00^{bc}$ | $1.88 \pm 0.01^{h}$ | $2.30 \pm 0.00^{ef}$ | $1.00 \pm 0.06^{a}$ | $1.20 \pm 0.00^{ab}$ | $82.70 \pm 0.41^{ab}$ | $89.40 \pm 0.46^{bcd}$ |
| June, 2013 | $10.10 \pm 0.01^{ab}$ | $1.42 \pm 0.01^{f}$ | $2.10 \pm 0.00^{de}$ | $1.00 \pm 0.12^{a}$ | $1.00 \pm 0.00^{a}$ | $84.28 \pm 0.13^{e}$ | $89.60 \pm 0.17^{cde}$ |

∗ MC= Moisture content, CP = Crude protein, FC= Crude fat, CF = Crude fibre, CHO= Carbohydrate and TS = Total solid
∗ Values are means of triplicate determinations ± Standard error (Mean ± SEM)
∗ Means followed by the same superscript in each column are not significantly different at P<0.05 as assessed by LSD, Tukey and Duncan's Multiple Range Test (DMRT)

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