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Aflatoxin, Nutritive Values and Microbiological Status of Stored Cakes of Some Selected Nigerian Oil Seeds

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Abstract - Defatted ground nut, soybean and palm kernel cakes were stored for three months at ambient, refrigeration and display conditions. Samples were assayed for nutritive, aflatoxins and microbiological properties. Proximate parameters significantly ($p<0.05$) reduced with storage. Mineral composition reductions of 3.0-35.00%, 1.2-18.75% and 6.2-64.25% were observed for ambient, refrigeration and display condition storage respectively. There was a significant ($p<0.05$) increase in both bacterial and fungal counts with increased storage duration. Aflatoxin B1 contents of 21.65-49.26, 14.57-27.24 and 29.14-61.32 **µ**g/kg were detected in cakes stored at room, refrigeration and display condition respectively while the Aflatoxin B2 contents were 9.85-14.13, 3.24-10.02 and 12.96-17.04 **µ**g/kg respectively. Proper storage/handling of feed ingredients should form a core component of Good Manufacturing Practice (GMP) of feed production in tropical countries. The regulatory agencies in these countries should enforce a revised GMP in order to guarantee a more healthy and productive populace.

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I. Introduction

Good nutrition is a basic human right. In order to have a healthy population that can promote development, the relationship between food, nutrition and health should be reinforced (Achu et al. 2005). An important way of achieving this in developing countries is through the exploitation of available local resources (Achu et al. 2005; Kolapo and Sanni, 2005).

Oil crops and their products have diverse applications in human endeavors, and this may have qualified them as the second most valuable commodity in the world trade. In addition to the immense usefulness of the oils from oilseeds, the defatted residues of the oilseeds are used to prepare food for children, pregnant and lactating mothers, old people as well as dietary supplement to be used in human food system as biscuit, soap and snack in Nigeria (Akano and Atanda, 1990; Oladimeji and Kolapo, 2008). Not until recently that the use of cassava starch in compounding animal feed is gaining prominence in the developed world, the use of defatted oilseed for compounding livestock feed is a global practice. However, the substantial portion of animal feeds produced in developing world used defatted oilseed as the major raw materials. For instance, Oluwafemi and Dahunsi (2009) reported that groundnut cake, palm kernel cake and maize are the main ingredients of local feeds in Nigeria.

The literature is replete with reports on the qualities of extracted oils from the oilseed while there is scanty information on the storage qualities of these cakes. Previous report from our laboratory indicated that within one month of storage, there was significant microbial proliferation and subsequent reduction in nutritive properties of stored cakes (Oladimeji and Kolapo, 2008). Based on our interaction with some feed mills in Nigeria, it is evident that defatted seed cakes are used between one to three months of their production. Also, the manner of handling these cakes prior to use appeared to make them a great threat to public health. For example, it is not uncommon for some feed mills to stack the defatted cakes which are intended for use outdoor until the time of usage.

Therefore, the present study is designed to evaluate the effect of such relatively long term storage and manner of handling on the nutritive, aflatoxin and microbiological properties of defatted cakes of three oilseeds namely, groundnut, soybean and palm kernel.

II. Materials and Methods

a) Collection of Oil seeds, Oil Extraction and Storage of Defatted Residues

Samples of three oilseeds namely, groundnut, soybean and palm kernel were purchased from local markets in Ibadan, Nigeria in April 2008. Ibadan has a tropical climate which is characterized by dry November to April and wet May to October seasons. The mean annual rainfall of 1150-1500 mm occurs mainly between April and October with major peak in June.

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The samples were dehulled, sundried for 48-72 h and ground in a Kenwood blender to reduce their particles size so as to improve yield. The oils were obtained by cold solvent extraction of the ground samples using n-hexane. Two hundred milliliters of n-hexane was mixed with 500gm of each sample in five batches. The mixture was shaken vigorously and left for about 72 h to settle. The supernatant was slowly decanted and poured into a sterile reagent bottle. The extract from all the five batches were pooled together and allowed to settle again for 24 h. The mixture was distilled by simple distillation. The recovered oil was transferred into sterile bottle, while recycled n-hexane was kept for further extraction. Defatted residues were dried in an oven at 40^0C for five days to obtain residues of between 3.65 and 5.18% moisture content. Cakes of each of the investigated oilseeds were divided into three portions and packed separately inside a sterile polypropylene bag, with each portion stored under different storage conditions for three months. A portion was kept inside a cupboard (room temperature); the second was kept in a refrigerator while the remaining portion was kept outdoor under the sun thus simulating the display condition as practiced by some feed mills in Nigeria. The storage experiments were carried out between April and July 2008. The mean weather conditions for April, May, June and July 2008 were: relative humidity, 80, 79, 85 and 88%; temperature, 23.7-32.7, 23.1-31.9, 22.7-30.4 and 22.5-29.1 ºC respectively.

b) Nutrient Analysis

AOAC (1987) methods were used for the determination of proximate parameters such as fat content, ash content and moisture content. All the samples were analyzed for the following nutrients: N, P, Ca, Mg, K, Na and Fe.

For both N and P analyses, the samples were first digested in a hot sulphuric acid solution with SeO_2 catalyst using a method adapted from Novozamsky et al. (1983) and the ensuing solution was used for subsequent analyses. For P analysis, the ascorbic acid method adapted from Murphy and Rilly (1962) using an acid molybdate solution was employed; while the popular Berthalot (Indophenol reaction) method adapted from Searle (1984) was used for N analysis and the crude protein (NX6.25) was estimated .

Other nutrients were determined sequel to ashing in a muffle furnace (500 ºC). The methods described by Jones and Case (1990), and Hunter et al. (1984), were used for the nutrient analysis.

c) Microbiological Assays of Stored Defatted Residues

The method of Omafuvbe et al. (2000) was adapted for the enumeration of microbial population in the stored defatted residues. Counts were taken at one month interval. Counted bacteria colonies were expressed as colony forming unit per gramme (cfu/g) of samples. Mean values of triplicate plates were recorded. For the fungal counts, potato dextrose agar (PDA) and incubation temperature of 28 ºC for 2-3 days were used. Pure cultures of the isolated bacteria and fungi were obtained by repeated streaking. Bacterial isolates were characterized and identified according to Cowan and Steel (1985) and definition given with reference to Bergey's manual (Sneath et al. 1986). Fungal isolates were identified using the key given by Onions et al. (1981).

d) Detection of Aflatoxins Using Thin layer Chromatography

The method described by Seitz and Mohr (1977) was used for detecting aflatoxins in the pulverized stored samples. Aflatoxins were identified on the basis of co-migration with aflatoxin standards (Fluka) and their characteristics fluorescent color under long Ultra Violet (UV) light at a distance of 360 mm. The concentration of aflatoxins (B_1 and B_2) in the extract was determined by measuring its absorbance at 360 mm and then calculated according to the method of Masri et al. (1969).

e) Statistical Analysis

The statistical analysis of the data was by Analysis of Variance (ANOVA) using 5% level of significance. A Two-way ANOVA analysis was used to test for significance of difference between the storage conditions and between the types of defatted residues.

III. Result and Discussion

The proximate compositions of defatted groundnut, soybean and palm kernel cakes stored for three months are shown in Table 1. A two way ANOVA test of the data depicted that with increased storage time, the proximate parameters (such as crude protein, fat, ash and fiber) were significantly ($p<0.05$) reduced while the moisture contents correspondingly increased. Of all the proximate parameters, the highest significant ($p<0.05$) reduction was observed in the fat content of the cakes stored at display condition. A comparison between the three stored defatted cakes revealed that soybean cake exhibited the most significant ($p<0.05$) reduction in nutritive parameters during the three months storage.

The observed trend of reduction in nutritive qualities is in agreement with previous reports on some selected stored defatted oilseed cakes (Oladimeji and Kolapo, 2008) and soybean daddawa (Kolapo and Sanni, 2007). In those reports, microbial proliferation and subsequent nutrients utilization were suggested to be most probably responsible for the observed nutrient depletion. The main factors that cause rancidity/deterioration of fat are moisture, bacteria, enzymes, light, heat, air and some types of metal (ITDG, 2005). Given that the relative humidity of between '79 and 88%; and temperature of between 24-30 ºC and 23-29 ºC were recorded during the storage experiment, the significant fat depletion observed in the cakes stored

at display condition might also be partly owned to fat rancidity. Meanwhile, rancid oil forms harmful free radicals in the body, which are known to cause cellular damage and have been associated with diabetes, Alzheimer's disease and other conditions. Rancid oils can also cause digestive distress and deplete the body of vitamins B and E as well as causing damage to DNA, accelerate aging, promote tissue degeneration and foster cancer development (Kalmus, 2011). It then appears that the storage of cakes at display condition such as the simulated in the present work might be of public health concern.

Table 2 shows the mineral compositions of defatted cake of groundnut, soybean and palm kernel stored for three months. Both the length of storage and storage conditions significantly ($p<0.05$) affected the mineral contents of the stored defatted cakes. There were significant reductions ($p<0.05$) in the mineral compositions of stored cake with increasing length of storage. In this regard, the cakes stored under display condition were mostly affected. For instance, mineral composition reductions of 3.0-35.00%, 1.2-18.75% and 6.2-64.25% were observed for ambient, refrigeration and display condition storage respectively. The observed mineral contents reduction of the stored cakes could be attributed to the involvement of these minerals in the metabolism of the proliferating micro biota. The favorable nutritive content of defatted oilseed cake qualifies them to find application in the production of animal feeds (Achu et al. 2005; Oladimeji and Kolapo, 2008). It is now becoming evidently clear that the practice of leaving these cakes outdoor prior to use as being done by some feed mills in Nigeria is having a great negative impact on the nutritive quality of feeds obtained from such mishandled cakes.

The result of microbial counts of stored defatted cakes of groundnut, soybean and palm kernel is shown in Table 3 while the associated bacteria and fungal species are shown in Table 4. There was a significant ($p<0.05$) increase in both bacterial and fungal counts with increased storage duration. The cakes stored under display conditions had the highest microbial counts while those stored under refrigeration condition had the least counts. At the end of the three months of storage, the mould count obtained from stored cake is one-tenth fold less than the range (1.1- 9.5 X 105 cfu/g) obtained for fish feed in Nigeria (Oluwafemi and Dahunsi, 2009). The micro flora of the stored defatted cakes in the present study is similar to those found to be associated with groundnut and its products (McDonald, 1964; Akano and Atanda, 1990), maize (Prasad, 1992),

Table 1: Proximate compositions (%) of defatted groundnut, soybean and palm kernel cakes stored for three months

	Room Temperature Storage time (month)				Refrigeration Temperature Storage time (month)				Display Condition Storage time (month)			
Nutrient	0	1	2	3	0	1	2	3	0	1	2	3
					Defatted Ground nut cake							
Protein	48.47^{a}	47.25^{ab}	46.88^{ab}	46.24^{b}	48.47^{a}	47.95^{ab}	47.21^{ab}	46.86^{b}	48.47^{a}	47.25^{ab}	46.88^{ab}	46.24^{b}
Fat	9.87^{a}	9.81^{a}	9.16^{ab}	9.11^{ab}	9.87	9.85^{a}	9.24^{a}	9.13^{ab}	9.87^{a}	9.61^{a}	9.08^{ab}	8.92^{b}
Ash	4.87^{a}	4.76^{a}	4.71^{a}	4.49^{ab}	4.87	4.84^{a}	4.76^{a}	4.58^{ab}	4.87^{a}	4.63^{ab}	4.59^{ab}	4.31^{b}
Fiber	3.56^{a}	3.44^{ab}	3.41^{ab}	3.36^{b}	3.56	3.51^{a}	3.47^{ab}	3.39^{ab}	3.56^{a}	3.35^{ab}	3.39^{ab}	3.18^{b}
Moisture	3.65^{e}	4.87^{cd}	5.21^{c}	5.61^{c}	3.65	3.79^{e}	4.19^{d}	5.24^{c}	3.65^{e}	6.16^{bc}	6.82^{b}	7.45^{a}
					Defatted Soybean cake							
Protein	41.30^{a}	39.55^{a}	37.24^{b}	36.29^{bc}	41.30^{a}	40.25^{a}	38.76^{ab}	37.64^{b}	41.30^{a}	38.50^{ab}	36.92^{bc}	35.29^{c}
Fat	17.65^{a}	17.47^{a}	17.12^{a}	16.98^{b}	17.65^{a}	17.59^{a}	17.43^{a}	17.31^{a}	17.65^{a}	17.39^{a}	17.08^{ab}	15.92^{c}
Ash	3.61^{a}	3.45^{a}	3.42^{a}	3.22^{ab}	3.61^{a}	3.53^{a}	3.47^{a}	3.33^{ab}	3.61^{a}	3.37^{ab}	3.34^{ab}	3.15^{b}
Fiber	4.35^{a}	4.18^{ab}	4.12^{ab}	3.94^{b}	4.35^{a}	4.26^{a}	4.22^{a}	4.15^{ab}	4.35^{a}	4.15^{a}	3.91^{b}	3.54^{b}
Moisture	5.18^{de}	6.80^{bc}	8.13^{a}	8.28^{a}	5.18^{de}	5.37^{d}	6.26^{c}	7.31^{b}	5.18^{de}	6.80^{bc}	8.13^{a}	8.28^{a}
					Defatted Palm Kernel cake							
Protein	19.31^{a}	17.85^{b}	17.43^{b}	16.44^{c}	19.31^{a}	18.55^{ab}	17.97^{b}	16.89^{c}	19.31^{a}	16.80^{c}	16.25^{c}	15.96^{d}
Fat	7.91^{a}	7.81^{a}	7.18^{b}	7.05^{bc}	7.91^{a}	7.79^{a}	7.65^{ab}	7.40^{ab}	7.91^{a}	7.65^{ab}	7.20^{b}	6.74^{c}
Ash	5.61^{a}	5.36^{ab}	5.31^{ab}	5.09^{bc}	5.61^{a}	5.41^{a}	5.38^{ab}	5.16^{b}	5.61^{a}	5.29^{b}	5.26^{b}	4.92^{c}
Fiber	9.08^{a}	8.74^{ab}	8.69^{ab}	8.53^{b}	9.08^{a}	8.83^{a}	8.76^{ab}	8.66^{b}	9.08^{a}	8.62^{b}	8.56^{b}	8.39^{c}
Moisture	4.85^{d}	5.82^{c}	7.37^{ab}	7.33^{ab}	4.85^{d}	4.96^{d}	5.12^{cd}	6.18^{bc}	4.85^{ad}	6.95^{b}	7.92^{a}	7.84^{a}

Values are means of three determinations. Within row, values with different superscripts differed significantly ($p<0.05$).

Table 2 : Mineral Composition (%) of defatted ground nut, soybean and palm kernel cakes stored under different conditions for three months.

	Room Temperature Storage time (month)				Refrigeration Temperature Storage time (month)				Display Condition Storage time (month)			
Nutrient	0	1	2	3	0	1	2	3	0	1	2	3
					Defatted Ground nut cake							
Sodium	0.014^{a}	0.011^{b}	0.009^{c}	0.007^{d}	0.014^{a}	0.012^{a}	0.010^{b}	0.009^{c}	0.014^{a}	0.010^{b}	0.008^{cd}	0.005^{e}
Potassium	0.014^{a}	0.012^{a}	0.010^{b}	0.008^{cd}	0.014^{a}	0.012^{a}	0.009^{c}	0.007^{d}	0.014^{a}	0.011^{b}	0.008^{cd}	0.005^{e}
Calcium	0.014^{a}	0.012^{ab}	0.010^{b}	0.009^{c}	0.014^{a}	0.013^{a}	0.011^{b}	0.010^{b}	0.014^{a}	0.011^{b}	0.009^{c}	0.005^{d}
Phosphorus	0.493^{a}	0.482^{b}	0.480^{b}	0.478^{b}	0.493^{a}	0.492^{a}	0.491^{a}	0.487^{ab}	0.493^{a}	0.487^{ab}	0.478^{b}	0.462^{c}
Magnesium	0.032^{a}	0.028^{b}	0.025^{c}	0.023^{c}	0.032^{a}	0.032^{a}	0.028^{b}	0.026^{bc}	0.032^{a}	0.027^{b}	0.023^{c}	0.018^{d}
Iron	0.013^{a}	0.011^{ab}	0.009^{b}	0.006^{cd}	0.013^{a}	0.013^{a}	0.012^{a}	0.011^{ab}	0.013^{a}	0.010^{b}	0.007^{c}	0.004^{d}
					Defatted Soybean cake							
Sodium	0.036^{a}	0.032^{b}	0.030^{bc}	0.028^{c}	0.036^{a}	0.035^{a}	0.032^{b}	0.030^{bc}	0.036^{a}	0.027^{c}	0.024^{d}	0.020^{e}
Potassium	0.036^{a}	0.033^{b}	0.032^{b}	0.030^{c}	0.036^{a}	0.034^{a}	0.033^{b}	0.031^{c}	0.036^{a}	0.032^{b}	0.030^{c}	0.027^{d}
Calcium	0.036^{a}	0.034^{a}	0.032^{ab}	0.030^{b}	0.036^{a}	0.035^{a}	0.034^{a}	0.033^{ab}	0.036^{a}	0.033^{ab}	0.030^{b}	0.026^{c}
Phosphorus	0.393^{a}	0.384^{b}	0.380^{b}	0.378^{bc}	0.393^{a}	0.391^{a}	0.388^{b}	0.386^{b}	0.393^{a}	0.380^{b}	0.375^{bc}	0.370^{c}
Magnesium	0.027^{a}	0.025^{ab}	0.022^{bc}	0.022^{bc}	0.027^{a}	0.026^{a}	0.025^{ab}	0.023^{b}	0.027^{a}	0.024^{b}	0.020^{c}	0.018^{d}
Iron	0.017^{a}	0.015^{a}	0.013^{b}	0.011^{c}	0.017^{a}	0.016^{a}	0.015^{a}	0.014^{b}	0.017^{a}	0.014^{b}	0.011^{c}	0.009^{cd}
					Defatted Palm kernel cake							
Sodium	0.020^{a}	0.018^{a}	0.018^{a}	0.016^{b}	0.020^{a}	0.017^{ab}	0.015^{b}	0.015^{b}	0.020^{a}	0.018^{a}	0.014^{b}	0.009^{c}
Potassium	0.020^{a}	0.018^{a}	0.016^{b}	0.013^{c}	0.020^{a}	0.019^{a}	0.018^{a}	0.015^{b}	0.020^{a}	0.015^{b}	0.011^{cd}	0.009^{d}
Calcium	0.020^{a}	0.018^{a}	0.016^{b}	0.014^{bc}	0.020^{a}	0.019^{a}	0.018^{a}	0.017^{b}	0.020^{a}	0.016^{b}	0.012^{c}	0.008^{d}
Phosphorus	0.779^{a}	0.774^{a}	0.770^{ab}	0.768^{b}	0.779^{a}	0.775^{a}	0.772^{a}	0.770^{ab}	0.779^{a}	0.768^{b}	0.762^{b}	0.758^{b}
Magnesium	0.043^{a}	0.039^{ab}	0.036^{b}	0.033^{b}	0.043^{a}	0.041^{a}	0.039^{ab}	0.036^{b}	0.043^{a}	0.035^{b}	0.030^{b}	0.025^{c}
Iron	0.018^{a}	0.016^{ab}	0.013^{b}	0.010^{c}	0.018^{a}	0.017^{a}	0.016^{ab}	0.014^{b}	0.018^{a}	0.014^{b}	0.010^{c}	0.009^{cd}

Values are means of three determinations. Within row, values with different superscripts differed significantly ($p<0.05$).

Table 3 : Microbial count (log cfu/g) of defatted ground nut, soybean and palm kernel cakes stored under different conditions for three months

Sample	Room Temperature Storage time (month)				Refrigeration Temperature Storage time (month)				Display Condition Storage time (month)			
	0	1	2	3	0	1	2	3	0	1	2	3
					Bacterial count							
Ground nut cake	2.22^{f}	3.64^{e}	4.50^{c}	5.28^{a}	2.22^{f}	3.28^{e}	4.20^{cd}	5.11^{b}	2.22^{f}	4.04^{d}	4.70^{c}	5.36^{a}
Soybean cake	2.57^{e}	3.94^{c}	4.63^{b}	5.38^{a}	2.51^{e}	3.51^{d}	4.32^{bc}	3.92^{c}	2.51^{e}	4.48^{b}	4.88^{a}	5.34^{a}
Palm kernel cake	2.26^{d}	3.08^{c}	3.34^{c}	5.20^{a}	2.26^{d}	3.45^{c}	3.63^{c}	5.13^{a}	2.26^{d}	4.48^{b}	4.79^{b}	5.38^{a}
					Fungal count							
Ground nut cake	2.00^{e}	3.08^{c}	4.28^{b}	5.34^{a}	2.00^{e}	2.78^{d}	3.08^{c}	5.04^{a}	2.00^{e}	3.62^{c}	4.32^{b}	5.30^{a}
Soybean cake	2.60^{e}	3.08^{d}	4.08^{b}	5.26^{a}	2.60^{e}	2.72^{e}	3.95^{c}	3.94^{c}	2.60^{e}	3.53^{d}	4.46^{b}	5.47^{a}
Palm kernel cake	2.48^{c}	3.34^{b}	3.81^{b}	5.34^{a}	2.48^{c}	2.60 ^{c}	3.96^{b}	5.08^{a}	2.48^{c}	3.78^{b}	3.97^{b}	5.34^{a}

Values are means of three determinations. Within row, values with different superscripts differed significantly ($p<0.05$).

cassava flour (Oboh et al., 2000), stored soya oil (Ilori et al.,2007), stored soybean daddawa (Kolapo and Sanni, 2006; Kolapo et al., 2007), soybean, groundnut, melon, coconut and cashew cakes (Oladimeji and Kolapo, 2008), stored groundnut, melon, coconut and cashew oil (Kolapo and Oladimeji, 2011).

Table 5 shows the aflatoxin status of defatted oilseed cakes of groundnut, soybean and palm kernel stored under different conditions. Both the length and condition of storage significantly ($p<0.05$) affected the aflatoxin status of the stored cakes. The aflatoxin concentration in the stored cakes increased significantly ($p<0.05$) as storage progressed. Production of aflatoxin was highest in the samples stored under display condition, while the refrigerated samples had the least quantities of aflatoxins.

Aflatoxin B_1 (AFB_1) contents of 21.65-49.26, 14.57-27.24 and 29.14-61.32 μg/kg were detected in cakes stored at room, refrigeration and display temperature respectively. In addition, the Aflatoxin B_2 (AFB_2) contents detected in the samples stored under the same storage conditions were respectively 9.85-14.13, 3.24-10.02 and 12.96-17.04 μg/kg.

The present result is in agreement with some documented reports. Dawlatana et al. (2000) reported aflatoxin contaminated rate of 65μg/kg in groundnut samples from Bangladesh while aflatoxin concentration of 162 μg/kg was reported in Gambian groundnut samples (Hudson et al., 1992; Williams et al., 2004). Bankole and Mabekoje (2003) reported that yam chips had an aflatoxin contamination level of 4-186 μg/kg as Jimoh and Kolapo (2008) reported the presence of AFB_1 in groundnut and yam chips at the concentrations of 7-24 μg/kg and 14 μg/kg respectively in Nigeria.

Based on field report, the nutritional and physiopathological implication of aflatoxin as an environmental pollutant and feed contaminant in Nigeria has been discussed by Aletor (1990) and Atawodi et al. (1994). In a recent study, Oluwafemi and Dahunsi (2009) reported that most feeds imported into Nigeria had low aflatoxin levels compared to feeds formulated in Nigeria. In another development, Bankole et al. (2004) had earlier opined that the high level of aflatoxin contamination of feeds and feedstuff in West Africa countries could be attributable to the tropical climates, poorly developed processing facilities, storage and skilled human resources. The present study has scientifically confirmed that the storage/handling practices to which the feed ingredients are subjected to prior to feed production is critical to determining the aflatoxin contents of the final feed. Hence, proper storage of feed ingredients should form a core component of Good Manufacturing Practice (GMP) of feed production in these West African countries.

As efforts at ameliorating the aflatoxin levels in feed value chain increase, the unskilled human resources which manned various cottage feed mills in

Nigeria and other developing world must be educated on the negative consequences of their unwholesome practice of leaving their feed ingredients outdoor until use. And if possible, the regulatory agencies in these countries should enforce a revised GMP as proposed earlier in order to guarantee a more healthy and productive populace.

Table 4 : Microbial profile of stored defatted ground nut, soybean and palm kernel cakes

Sample	Bacterial Isolates	Fungal Isolates
Groundnut cake	*Staphylococcus saprophyticus, Bacillus subtilis, B. licheniformis, B. alveoli, Micrococcus luteus*	*Rhizopus oryzae, Fusarium poae, Aspergillus flavus, A . melleus, A. restrictus, Candida crusei*
Soybean cake	*Proteus mirabilis, Pseudomonas fluorescens, P. aeuroginosa, Bacillus alveoli*	*Rhizopus oryzae, Penicillium herqui, Aspergillus, flavus, A. niger, Candida valida, C. crusei*
Palm kernel cake	*Staphylococcus saprophyticus, Proteus mirabilis, Pseudomonas fluorescens, P. aeuroginosa, Bacillus alveoli*	*Neurospora sitophilus, Candida valida, Aspergillus flavus A. niger, Penicillium actrovercetum*

Table 5 : Aflatoxin (B1 & B2) contents (µg/Kg) of defatted ground nut, soybean and palm kernel cakes stored under different conditions for three months

	Room Temperature Storage time (month)				Refrigeration Temperature Storage time (month)				Display Condition Storage time (month)			
Sample	0	1	2	3	0	1	2	3	0	1	2	3
					Aflatoxin B1							
Groundnut cake	-	34.29^{d}	41.35^{c}	49.26^{bc}	-	22.46^{e}	25.16^{e}	27.24^{e}	-	48.66^{c}	53.84^{b}	61.32^{a}
Soybean cake	-	26.78^{d}	32.74^{c}	41.62^{b}	-	18.94^{f}	20.32^{ef}	22.44^{e}	-	33.25^{c}	42.66^{b}	51.77^{a}
Palmkernel cake	-	21.65^{d}	27.65^{c}	35.28^{b}	-	14.57^{e}	17.68^{e}	20.12^{d}	-	29.14^{c}	37.28^{b}	44.29^{a}
					Aflatoxin B2							
Groundnut cake	-	11.26^{bc}	12.76^{b}	13.85^{b}	-	8.27^{d}	9.34^{c}	10.02^{c}	-	13.25^{b}	14.69^{a}	16.13^{a}
Soybean cake	-	12.14^{c}	13.18^{b}	14.13^{b}	-	6.28^{e}	7.14^{de}	9.28^{d}	-	14.29^{b}	15.37^{ab}	17.04^{a}
Palm kernel cake	-	9.85^{c}	12.94^{b}	13.97^{b}	-	3.24^{e}	6.54^{d}	8.35^{c}	-	12.96^{b}	13.41^{b}	15.29^{a}

Values are means of three determinations. Within row, values with different superscripts differed significantly ($p<0.05$).

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