QUALITY ASSESSMENT OF PEELED AND UNPEELED ROASTED GROUNDNUT (*Arachis hypogaea* L.) SOLD IN BENIN CITY, NIGERIA.

***AKINNIBOSUN, F. I. AND OSAWARU, E. E.**

Department of Microbiology, Faculty of Life Sciences, University of Benin, P.M.B 1154, Benin City, Edo state, Nigeria

ABSTRACT

The microbiological quality of peeled and unpeeled roasted groundnut sold in Benin metropolis of Nigeria was investigated using standard microbiological methods. The microbial load of the roasted groundnut samples analysed differed. The bacterial counts ranged from 5.0 x 10^3 to 2.1 x 10^4 cfu/g and 1.1 x 10^4 - 4.6 x 10^4 cfu/g for unpeeled and peeled groundnuts respectively while the fungal count ranged from 3.4 x 10^4 to 6.6 x 10^4 cfu/g and 6.3 x 10^4 to 9.8 x 10^4 cfu/g for unpeeled and peeled groundnut samples respectively. Peeled groundnut samples had higher count of microbial load than the unpeeled groundnut. The bacterial isolates found associated with these groundnut products included Staphylococcus aureus, Bacillus subtilis, Micrococcus sp., Streptococcus sp. and Proteus vulgaris. The fungal isolates were Aspergillus flavus, Aspergillus niger, Neurospora sp., Mucor sp., Rhizopus sp., Penicillium sp., Trichoderma sp. and Fuasrium sp. Therefore, there is a need to educate both vendors and consumers of these snacks on food handling procedures and personal hygiene so as to minimize contamination.

KEY WORDS: Roasted groundnut, Peeled, Unpeeled, Quality assessment, Microbial contamination.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a nutrient dense agricultural produce belonging to the fabaceae family. It occupies an important position in the economy of developing nations and was first introduced in Nigeria in the 16th century (Adebesin *et al*., 2001). It has been estimated that about 1.4 million hectares are cultivated for groundnut in Nigeria mostly in the northern part. In developing countries, peanuts (groundnut) play important roles both as oil and food crop, providing high-quality cooking oil and an important source of protein for both human and animal diet. And as such a lot of peanut delicacies such as groundnut soup and snacks have been developed (Henshaw and Agunbiade, 2004). Groundnuts are also used as major ingredients in the formulation of weaning food with other cereals such as sorghum, corn, and millets because of their high protein and omega 6 fatty acid contents. They are also consumed roasted and boiled. Roasted groundnut is always relished and packaged in bottles. They are used in many homes as refreshments, to entertain visitors and as food. Groundnut snacks are consumed on a regular basis by both the young and elderly (IFIS, 2005). Groundnut and its derivatives are often hawked on the streets of urban areas and classified as street food. Street food satisfies a vital need of the urban population by being reasonably affordable and conveniently available, and some segments of the population depend entirely on it (Donker *et al*., 2009). Over the years there have been several issues concerning the nutrition and health safety of street foods owing to methods of processing and hygienic practices of the vendors (Amusa and Odunbaku, 2009).

Groundnut (*Arachis hypogea* L.) a valuable legume crop, is cultivated over an area of 99.4 hectares in Pakistan with a production of about 1017 kg/ hectare or 101 tones during 2001-2002. Groundnut seed contain 50% edible oil. Seeds are rich in fats, protein, vitamin B1, B2, B6, nicotinic acid and other vitamins. It is also a good source of lecithin present to the extent of 0.5-0.7% in decorticated nuts. Peanut butter has become a common edible diet. Groundnut cake has high nutritive value. Groundnut flour is suitable for supplementing white flour. Of the various disease causing organisms, *Fusarium solani*, *F. oxysporum* cause damping off of groundnut seedlings (Reddy and Rao, 1980). *Aspergillus flavus* attacks germinating groundnut seed (Clinton, 1960). *Aspergillus niger* caused disease rot of groundnut (Gibson, 1953). Mould fungi

are also known to produce mycotoxin. Many studies have detected different mold fungi and their toxin production ability in stored grains, which deteriorate the stored products (Afzal *et al*., 1979, Vedahayagam *et al*., 1989).

Groundnut occupies an important position in the economy of developing nations. The major groundnut producing countries are India, China and the United States. It was introduced into Nigeria in the 16th century and it has been estimated that about 1.4 million hectares are cultivated for groundnut in Nigeria (Afzal *et al*., 1978). Groundnut is nutrient dense agricultural produce, which is very high in energy due to its high fat and protein content. The carbohydrate content of groundnut is relatively low, being under 30% of the whole nut. The nut has relatively high content of fiber. It is an industrial crop whose major utilization is a source of oil. (Abalaka and Elegbede, 1981). Groundnut is widely consumed in Nigeria as roasted or boiled nuts, which could be cooked or eaten with boiled maize in the Western and Southern parts of the country (Kayode *et al*., 2011). Groundnut cake is the residue obtained after the extraction of oil and it is high in protein and used as supplement in feed and food. The groundnut cake is usually roasted in oil and is used as a delicious snacks or food supplement (Ocheme *et al*., 2014). As a result of improper processing and storage conditions, groundnuts and its products may be contaminated with microorganisms. The number and type of microorganisms present on the produce is important in deterioration and numerous molds may be involved, but most common are species of *Aspergillus, Penicillum* and *Fusarium* (Frazier and Westhoff, 1978; Sofroni *et al*.,2008). Abalaka and Elegbede (1981) isolated species of *Bacillus*, *Salmonella*, *Pseudomonas, Staphylococcus aureus* and *Escherichia coli* from groundnuts. The major factors which lead to high contamination levels of groundnuts are shell damage, and kernel splitting (usually induced by insects) poor harvesting and drought, (Elegbede, 1998; Ukwuru and Acholo, 2010). Under adverse conditions *Bacillus subtilis* is able to form spores (Adams and Moss, 2008). The aim of this research was to assess the quality of peeled and unpeeled roasted groundnut sold and consumed in Benin City, Nigeria.

MATERIALS AND METHODS

Collection of samples:

Samples of roasted groundnut (peeled and unpeeled) were obtained randomly from vendors in Benin metropolis. The groundnut samples were transported in sterile polyethylene bags to the laboratory immediately for analysis.

Preparation of groundnut samples

The samples were grinded using laboratory mortar. From each grinded sample 10 g was aseptically weighed and 90 ml of sterile distilled water was added to prepare a stock solution. Sterile dilution was carried out using sterile distilled water as diluents. Using separate sterile pipette, ten-fold dilutions of 10^{-1}, 10^{-2} and 10^{-3} were prepared as appropriate by transferring 1.0 ml of previous dilution to 9.0 ml of distilled water.

Preparation of culture media

All media were prepared accordingly to manufacturer's instruction. The media used in this study were Nutrient agar (used for heterotrophic bacterial count) and potato dextrose agar (used for fungal count).

Isolation and enumeration of microorganisms

One millilitre from 10 dilutions was plated out by pour plate method on nutrient agar and potato dextrose agar. The nutrient agar plates were incubated at 37 ^{0}C for 24hrs while the potato dextrose agar plates were incubated at room temperature 28 ^{0}C for 72hrs. After incubation, discrete colonies of culture on nutrient agar and potato dextrose agar plates were counted and expressed in cfu/ml.

Characterization and identification of bacterial isolates

Bacterial isolates were identified on the basis of cultural, morphological and biochemical tests according to Jolt *et al*., 1994 and Cheesbrough, 2006. The fungal colonies were identified as described by Harrigan, 1998.

RESULTS

The heterotrophic bacterial counts ranged from 5.0 x 10^3 to 2.1x10^4 cfu/g and 1.1x10^4 to 4.6x10^4 cfu/g for unpeeled and peeled groundnuts (Table 1). The fungal counts ranged from 3.4 x 10^3 to 6.6 x 10^4 cfu/g and 6.3 x 10^4 to 9.8 x 10^4 cfu/g for unpeeled and peeled groundnuts (Table 2). The fungal loads of the groundnut samples for both peeled and unpeeled were comparably

higher than the bacterial loads of the groundnuts. The microorganisms isolated from the groundnut samples included five bacterial isolates and seven fungal isolates (Table 3). The bacterial isolates were *Staphylococcus aureus*, *Bacillus subtilis*, *Micrococcus* sp., *Streptococcus* sp. and *Proteus vulgarus*. The fungal isolates were *Aspergillus flavus*, *Aspergillus niger*, *Neurospora* sp., *Mucor* sp., *Penicillium* sp., *Trichoderma* sp. and *Fusarium* sp. The occurrence of the microbial isolates is shown in Table 4. The predominant bacterial isolate in Table 5 was *S. aureus* (12.24%) followed by *Bacillus subtilis* (10.20%) and *Streptococcus* sp. (8.16%). Table 5 also shows the percentage occurrence of the fungal isolates and the predominant fungal isolate and highest occurring organism was *Aspergillus flavus* (18.37%) followed by *Aspergillus niger* (14.29%).

Table 1: Bacterial count of roasted groundnut

	Bacterial count (cfu/g)	
Samples	**Peeled**	**Unpeeled**
1	2.9×10^4	1.0×10^4
2	1.6×10^4	5.0×10^3
3	3.4×10^4	1.6×10^4
4	4.6×10^4	1.2×10^4
5	4.4×10^4	1.1×10^4
6	1.1×10^4	5.0×10^3
7	3.5×10^4	1.7×10^4
8	2.5×10^4	1.0×10^4
9	4.3×10^4	2.1×10^4

Key:

1 = Upper Sakponba groundnut
2 = UBTH groundnut
3 = Ekiosa groundnut
4 = Uselu market groundnut
5 = Agbor park groundnut
6 = Mission road groundnut
7 = Ogida barracks groundnut
8 = Uwelu market groundnut
9 = Adolor junction groundnut

Table 2: Fungal count of roasted groundnut

	fungal count (cfu/g)	
Samples	**Peeled**	**Unpeeled**
1	7.1×10^4	5.9×10^4
2	8.6×10^4	2.2×10^4
3	8.2×10^4	4.3×10^4
4	9.8×10^4	6.5×10^4
5	8.7×10^4	5.3×10^4
6	6.3×10^4	3.4×10^3
7	9.3×10^4	4.5×10^4
8	7.7×10^4	5.1×10^4
9	8.5×10^4	6.6×10^4

Key:
1 = Upper Sakponba groundnut
2 = UBTH groundnut

3 = Ekiosa groundnut

Bacteria	Fungi
Staphylococcus aureus	*Aspergillus flavus*
Bacillus subtilis	*Aspergillus niger*
Micrococcus sp.	*Neuropsora* sp
Streptococcus sp.	*Trichodema* sp.
Proteus vulgaris.	*Penicillium* sp.
	Fusarium sp
	Mucor sp.

4 = Uselu market groundnut
5 = Agbor park groundnut
6 = Mission road groundnut
7 = Ogida barracks groundnut
8 = Uwelu market groundnut
9 = Adolor junction groundnut

Table 3: Bacteria and fungi isolated from samples

Table 4: Occurrence of the microbial isolates in the roasted groundnut samples

Isolates	1	2	3	4	5	6	7	8	9
Staphylococcus aureus	+	+	-	+	+	-	+	-	+
Bacillus subtilis	-	-	+	+	-	+	-	+	+
Micrococcus sp.	-	-	-	-	+	-	+	-	-
Streptococcus sp.	+	-	+	+	-	-	-	+	-
Proteus sp.				+	-	-	-	-	-
Aspergillus flavus	+	+	+	+	+	+	+	+	+
Aspergillus niger	+	+	+	+	-	+	+	+	-
Neurospora sp	-	-	-	-	+	-	-	-	-

Trichodema sp.	-	-	-	+	-	-	-	-	+
Penicillium sp.	+	-	+	-	+	-	+	-	+
Fusarium sp	-	+	-	+	-	+	-	-	-
Mucor sp.	+	-	-	+	-	-	-	+	+

Key:
1 = Upper Sakponba groundnut
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Table 5: Percentage occurrence of the microorganisms isolated

Microbial isolates	Number of isolates	Frequency (%)
Staphylococcus aureus	6	12.24
Bacillus subtilis	5	10.20
Micrococcus sp.	2	4.08
Streptococcus sp.	4	8.16
Proteus sp.	1	2.04
Aspergillus flavus	9	18.37
Aspergillus niger	7	14.29
Neurospora sp	1	2.04

Trichodema sp.	2	4.08
Penicillium sp.	5	10.20
Fusarium	3	6.12
Mucor sp**.**	4	8.16
Total	49	**100.0**

DISCUSSION

The microbial quality and safety of vending operations are a major source of concern for food control and health officers in developing countries. This study reports the microbial quality of peeled and unpeeled roasted groundnuts hawked in the streets of Benin metropolis. The heterotrophic bacterial counts ranged from 5.0×10^3 - 2.1×10^4 cfu/g and 1.1×10^4 - 4.6×10^4 cfu/g for unpeeled and peeled groundnuts respectively. The heterotrophic fungal counts ranged from 3.4×10^3 - 6.6×10^4 cfu/g and 6.3×10^4 - 9.8×10^4 cfu/g for unpeeled and peeled groundnuts respectively. The fungal load of the groundnut samples for both peeled and unpeeled roasted groundnuts were comparably higher than the bacterial load of the groundnuts. This finding is similar to those reported by Adebesin *et al*., 2001, who found higher fungal load than bacteria load in a similar study in Bauchi, Nigeria. The peeled groundnuts had more microbial contamination than the unpeeled groundnut. This could be due to the processes involved in the peeling, which includes using dirty and unclean hands to peel and blowing air from the mouth to remove the peels, thereby introducing microbes from the hands and mouth to the peeled groundnut. The microorganisms isolated from the groundnut samples included five bacterial isolates and seven fungal isolates. The bacterial isolates were *Staphylococcus aureus*, *Bacillus subtilis*, *Micrococcus* sp., *Streptococcus* sp. and *Proteus vulgaris*. The fungal isolates were *Aspergillus flavus*, *Aspergillus niger*, *Neurospora* sp., *Mucor* sp., *Penicillium* sp., *Trichoderma* sp. and *Fuasrium* sp. This result is in agreement with findings of Adebesin *et al*. (2001) who reported the isolation of similar microorganisms from roasted groundnut sold in Bauchi, Nigeria.

The presence of the isolated bacteria species in these products is of particular interest because of their possible involvement in different infection. *Staphylococcus aureus* is known to cause enterotoxigenicity due to the production of enterotoxin. Some *Bacillus* species such as *B. cereus* are food poisoning bacteria, while others like *Bacillus substilis* causes miscellaneous problems (Abalaka and Elegbede, 1981). These bacteria pathogens are ubiquitous in nature and as such could be found in soil, dust, bodies of insects, animals and humans that handle the groundnuts and its products (Frazier and Westhoff, 1978). They could be transferred to groundnuts during storage and processing and some could be carried over from farm before harvest. *Staphylococcus* sp. have been isolated from soybean supplemented and unsupplemented maize products (Efiuvewevwere, 1999). The isolation and presence of *Aspergillus* sp. from all the groundnut samples confirmed the earlier reports of Dienar, (1960) and Dange and Patel, (1984) that *Aspergillus* sp. were the prominent fungi isolated from stored groundnut seeds. Bass, (1982) reported that the storage potential of groundnut grain is influenced by inherent as well as external factors, especially genetic differences between genera, species and cultivars. Some of these fungi isolated in this work have been reported as being associated with seeds in Nigeria and other parts of the world (Ito *et al*., 1998; Oluma *et al*., 2009). Mycoflora of groundnut are known to produce a large number of metabolites including aflatoxin. Aflatoxin contamination of groundnut is of significance in relation to public health and future export trade. Aflatoxin contamination of groundnut is one of the most important constraints to production in many West African countries (Mehan *et al*., 1986). The toxin also constitutes a potential and even presents environmental hazard to animal and man alike (Waliyar, 1990). Aflatoxin is potent hepatocarcinogenic secondary metabolites produced by *Aspergillus* sp. These fungi occur on a number of agricultural commodities including groundnut. The use of stored food containing more than 20 ppb (μg/kg) aflatoxin for human consumption is prohibited in Mexico and other countries including United States of America. Grains with more than 20 ppb aflatoxin cannot be sold through interstate commerce, and some countries will not buy grain with contamination greater than 10 ppb (Rodriguez-del-Bosque, 1996).

Other effects of mycotoxins on human and animal health reported in medical literature include ergotism, hepatitis, tetratogenic, tremorgenic, skin diseases, gastroentritis, hemorrhage and vomiting (Shetty, 1992). In view of the statements by Alpert and Davidson (1969) that

mycotoxins are the important causes of primary liver cancer, mouldy foods and beverages should be considered dangerous and not to be consumed. The results of this study, therefore, suggest that some of the fungi were probably extraneous or just natural contaminants of groundnut seed. Mehan *et al.*, (1982) pointed out that some of the these fungi were probably only casually associated with groundnut but a large number of them have been consistently reported as members of shell (pod) and seed mycoflora of sound and diseased pods and may be said to pose an affinity for the groundnut pod. This is consistent with the conclusions of Agarwal and Sinclair (1987) that most seed-borne pathogens do not cause spoilage of the seed immediately until high microbial population is reached.

Microbial contamination of street-vended foods has been well documented and several outbreaks of disease, including cholera outbreaks, have been traced to its consumption (Barro *et al*., 2007). This is of major concern to FAO. The total plate count was observed to be within the microbiological standard for legume products (1 x 10^4 cfu/g). This may be attributed to the preservatives added during processing and the packaging. One of the reasons for such a discrepancy could be the fact that the microbiological load of these snacks is highly dependent on the processing steps undertaken, taking into consideration that in developing countries traditional methods of processing, packaging, and poor personal hygiene of food handlers are still observed during food marketing and technology (Witkowska *et al*., 2011; Barro *et al*., 2002). The observed high microbial loads of the groundnut samples indicate microbial contamination therefore, posing a health hazard to consumers, exposing them to a potential risk of acquiring food borne disease. Food-borne illness of microbial origin are a major international health problem associated to food safety in developing countries (WHO, 2002). Contamination of street-vended food has been attributed to exposure to polluted environment, poor sanitation and poor hygienic practices by the vendors (Mensah *et al*., 2002). There have been several suggested interventions to improve the hygiene of street foods, which includes (1) education and training programs for vendors, (2) the improvement of vendors' equipment for preparation and storage, (3) the provision of adequate sanitation and refuse disposal facilities, and (4) the provision of special food centers (WHO, 2002). WHO proposed the adoption of HACCP system in the street food control in order to improve the efficiency of the surveillance system by detecting the hazards and focusing on the critical control points (WHO, 2002). This approach can

be applied at any step of the food chain to identify and characterize the critical points where risk occurs and to establish priorities, formulate interventions and control. This information can be used to set priorities, formulate interventions, and identify the needs of vendors and customers for education and training (Draper, 1996).

CONCLUSION

The results of this study revealed the presence of bacterial and fungal contaminants in roasted groundnut sold in Benin City. The peeled roasted groundnut had more microbial contamination than the unpeeled roasted groundnut. The presence of microbial pathogens in the roasted groundnut samples is of public health concern and as such adequate quality control measures should be taken during the preparation of the groundnut.

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REFERENCES

Abalaka, J. A. and Elegbede, J. A. (1981). Aflatoxin distribution and total Microbial content in an edible oil extracting plant. *Journal of Food Chemistry and Toxicology* **20***:* 43-46.

Adams, M. R. and Moss, M. O. (2008). Food Microbiology (3rd edition). Royal Society of Chemistry, Cambridge, UK.

Adebesin, A.A., Saromi, O.T., Amusa, N. A. and Fagade, S.O. (2001). Microbiological quality of some groundnut products hawked in Bauchi, a Nigerian City. *The Journal of Food Technology in Africa* **6**: 53-55

Afzal, M. R., Cheema, A. and Chaudhary, R. A.. (1979). Incidence of aflatoxin producing fungi in animal feed stuff. *Mycopathologia*, **69**(3): 149-51.

Agarwal V. K. and Sinclarir J. B., (1987). Principles of Seed Pathology. Vol **II** CRC press inc. BOCA Roton; Florida. pp. 55-89.

Alpert, M. E. and Davidson, C. S. (1969). Mycotoxins, a possible cause of primary carcinoma of the liver. *American Journal of Medical* **46**: 326-329.

Amusa, N. A. and Odunbaku, O. A. (2009). Microbiological and nutritional quality of hawked kunun (a sorghum based non-alcoholic beverage) widely consumed in Nigeria. Pakistan Journal of Nutrition **8** (1): 20-25.

Barro, N., Bello, A. R., Itsiembou, Y., Savadogo, A., Ouattara, C. A. T., Nikiéma, A. P., De Souza, C. and Traoré, A. S. (2007). Street-vended foods improvement: Contamination mechanisms and application of food safety objective strategy : Critical Review. *Pakistan Journal of Nutrition* **6** (1): 1-10.

Bass, L. N. (1982). Physiological and other aspects of see preservation. Pp. 145-170. **In**: The plant seed, development, preservation and germination; Eds. I. Rubenstein; R.L. Pillips; C.E. Green and B.G. Gengenbach. Academic Press Inc., New York.

Cheesebrough, M. (2006). District laboratory practice in tropical countries. Cambridge University press, 434pp.

Clinton, R. S. S. (1960). Seed bed pathogen of groundnut in Sudan, and an attempt at control with an artificial testa. *Empire Journal of Experimental Agriculture* **28**: 211-222.

Dange, S. R. S and Patel, V. J. (1984). Effect of relative humidity and storage period on fungi invasion and viability of groundnut seeds. *Bulletin of grain Technology (India)* **22**: 225-231.

Dienar , U. L. (1960). The mycoflora of peanut in storage. *Phytopathology* **50**: 220 – 223.

Donkor, E. S., Kayang, B. B., Quaye, J. and Akyeh, M. L. (2009). Application of the WHO keys of safer food to improve food handling practices of food vendors in a poor resource community in Ghana. *International Journal of Environmental Resources and Public Health.* **6:** 2833 – 2842.

Draper, A. (1996). Street foods in developing countries: the potential for micronutrient fortification. John Snow, Inc/OMNL Project, Pp 16.

Efiuvwevwere, B. J. O. (1999). Some Bacteria of food and Industrial importance Monograph series in food and Industrial microbiology Published by Paragraphics, Port Harcourt. 27 pp.

Elegbede, J. A. (1998). Legumes. *In*: Nutritional quality of plant foods. Osagie, A.U. and Eka, O.U. (Ed). Post harvest research unit, Department of Biochemistry, University of Benin, Benin City, Nigeria.

Frazier, W. C. and Westhoff, D. C. (1978). *Food Microbiology* 3rd Ed. Tata McGraw Hill Publ. Co. Ltd. New Delhi. pp. 17 - 34.

Gibson, I. A .S. (1953). Crown rot, a seedling disease of groundnut caused by *Aspergillus niger*. *Trans. British Mycology Society* **36**: 198-209.

Harrigan, W. F. (1998). Laboratory methods in Food Microbiology, 3rd edn. Academic Press, London. UK.

Henshaw, R. B. and Agunbiade, M. O. (2004).Food oils and fats technology: Utilisation and Nutrition. Chapman and Hall, England.

IFIS. (2005). Dictionary of food science and technology. Blackwell publishing, Oxford, UK.

Ito M. A., Bacchi L. M. A., Maringoni A. C. and Menten, J. O. (1992). Comparison for the detection of *Aspergillus* and *Penicillium* spp. on groundnut seed. *Suma Phytopathological (Brazil)* **18**: 262-268.

Jolt, J. G., Krieg, N. R., Smith, P. H. A., Stanley, J. T. and Williams, S. T. (1994). Bergey's manual of systemic bacteriology, 9th edn. Williams and Wilkins Co. Baltimore, Maryland.

Kayode, F. O., Oguntona, C. R. B., Elemo, G. N., Bankole, A. O. (2011). Chemical properties and microbial quality of peanut (Arachis hypogaea) snacks in Lagos metropolis. *Fermentation Technology and Bioengineering* **1**: 77 – 87.

Mehan V.K., McDonald, D. and Gibbion R.W. (1982). Seed colonization and aflatoxin production strains of *Aspergillus flavus*. *Oleaginaux* **37**: 183-191.

Mehan, V. K., McDonald, D. and Ramakrishna, N. (1986). Varietal resistance in peanut to aflatoxin production. *Peanut Science* **13**: 7-10.

Mensah, P., Yeboah-Manu, D., Owusu-Darko, K. and Ablordey, A. (2002). Street foods in Accra, Ghana: how safe are they? *Bullet World Heal Organization* **80 (7)** : 546-554.

Ocheme, O. B., Igyor, M. A. and Hassan, H. (2014). Isolation and characterization of microorganisms in dakuwa (a Nigerian cereal/ groundnut snack). *International Journal of Research in Pure and Applied Microbiology* **4 (1):** 15 – 19.

Oluma, H. O. A. and Nwankiti, A. N. (2000). *Macrophomina phaseolina* dry root and fruit rot of okra in Nigeria. *African Plant Protection (South Africa)* **6** (1):77-81 .

Reddy, M. N and Rao, A.S. (1980). Damping off of groundnut caused by 2 *Fusarium* spp., *F. solani* and *F. oxysporum*. *Indian Journal of Mycology and Plant Pathology* **10**(1): 65-66.

Shetty, H. S. (1992). Different types of damages in seeds caused by seed borne fungi. Pp. 53-62, *in*: Seed pathology. Proc. of Technical Center for Agricultural and Rural Cooperation. Seminar held in Copenhagen, Denmark. Eds. S.B. Mathur and J. Jorgensen. Technical Center for Agricultural and Rural Cooperation, Wageningen, Netherlands, 412 pp.

Sofroni, E., Bixing, H. and Ed, S. (2008). A survey of the bacteriological quality of preroasted peanut, almond, cashew, hazelnut and brazilnut kernels, received into three Australian nut-processing facilities over a period of 3 years, *Journal of Food Protection* **71 (2)**: 402 – 404.

Ukwuru, M. U. and Acholo, B. (2010). Effect of groundnut variety on the nutritive value, acceptability and storage stability of spiced fried groundnut paste. *Journal of Applied Science and the Environment* **2 (1)**: 6 – 9.

Vedahayagam, H.S., Indulkar, A. and Rao, S. (1989). The occurrence of *Aspergillus flavus* and aflatoxin in India cotton seed. *Journal of Food. Science and Technology* **23**(2): 73–76.

Waliyar, F. (1990). *Aspergillus flavus* and *A. niger* contamination of groundnut in Niger. Proc. Am. peanut Research Education Society. Annual meeting 22nd, *in*: *Plant Disease* 78: 704-707.

Witkowska, A. M., Hickey, D. K., Alonso-Gomez, M. and Wilkinson, M. G. (2011). The microbiological quality of commercial herb and spice preparations used in the formulation of a chicken supreme ready meal and microbial survival following a simulated industrial heating process. *Food Continental* **22**: 616 – 625.

World Health Organization (2002). WHO global strategy for food safety safer food for better health. World Health Organization, Geneva Switzerland. 10 pp.