Original Research Article

Functional and Proximate Composition of Sorghum Starch Complemented with Germinated Moringa Seed Flour

ABSTRACT

The effect of complementing sorghum starch with moringa seed flour on the functional and proximate composition of the blends was investigated. Sorghum grains were processed in to starch and moringa seed processed to flour. The following blends were formulated; 100:0, 97.5:2.5%, 95:5% and 92.5:7.5% for sorghum starch and moringa seed flour respectively. The samples were analyzed for functional properties and proximate composition using standard analytical procedure. Bulk density was in the range of 0.57g/ml to 0.63g/ml, swelling index was in the range of 8.06g/ml to 9.12g/ml, water absorption capacity was in the range of 1.60g/ml to 1.75 g/ml, oil absorption capacity was in the range of 1.00 g/ml to 1.30 g/ml, least gelation concentration was in the range of 8% to 10%. Moisture content was in the range of 7.2% to 8.8%, fat content ranged from 9.25% to 12.25%, fibre content was in the range of 3.01% to 3.2%, Ash content was in the range of 0.55% to 1.00%, protein content was in the range of 6.34% to 12.15%, carbohydrates content was in the range of 66.70% to 72.10%. Proximate composition parameters such as the fat content, protein content, ash content, fibre content, carbohydrate content increases significantly ($P \leq 0.05$) with an increasing percentage inclusion of moringa seed flour while the moisture content show a significant decrease ($P \leq 0.05$). The functional properties parameters varied with inclusion of moringa seed flour, bulk density increases while water and oil absorption capacities, swelling index and least gelation reduces with increasing percentage inclusion of moringa seed flour. However, it was only swelling index that shows a significant decrease ($P \leq 0.05$). The study shows that inclusion of moringa seed flour to sorghum starch significantly improve the proximate composition and functional properties of the blends.

Keywords: Bulk density, fat, fibre, protein, swelling index

INTRODUCTION

Sorghum is one of the essential crops in Africa, and the fifth most important cereal crop grown in the world especially in northern part of Nigeria (Zubair and Osundahunsi, 2016). Nigeria is the largest producer of sorghum in West Africa and it accounted for about 70% of the total sorghum output in the region (FAO, 2004). Sorghum can be processed into a variety of traditional foods including fermented and non-fermented products such as unleavened bread, porridge, cookies, cakes, cereal extracts, malted alcoholic and non-alcoholic beverages, '*tuwo*', '*akamu*', '*kunu*', '*ingera*', '*kisra*' and '*koko*' (Onimawo and Onofun, 2003). Sorghum is generally high in carbohydrate, low in quantity and quality protein that is limiting in lysine, threonine, methionine and tryptophan (Eckhoff and Watson, 2009). The germ fraction of sorghum is rich in minerals, protein and lipids as well as B-group vitamins: thiamine, niacin and riboflavin (Melaku *et al*., 2005).

Moringa is an underutilized plant, the whole seeds can be eaten green, roasted or powdered and steamed in tea and curries (Fahey, 2005). Moringa seed contain nutritional profile of important minerals, as well as good source good source of protein, vitamins, beta-carotene, amino acids and various phenolic compounds (Anjorin *et al*., 2010). With the aforementioned nutritional profile, blending sorghum powder with moringa seed flour will increase the nutritional potential of the final product (Anjorin *et al*., 2010). Moringa leaf can be eaten fresh or prepared similar to spinach and it contains over three times the amount of iron and vitamin A found in spinach as well as four times the amount of calcium found in cow's milk (Edward *et al*., 2005). Malnutrition in its various forms (kwashiorkor, beriberi, anemia, and scurvy) is a major factor in high rates of infant mortality, for instance, in West Africa; the choice of product to combat malnutrition must comply with certain criteria: accessibility, availability in the market, low cost, ease of preparation, general acceptance, and ease of cultivation and a product that can solves the problem in a lasting way might well be moringa (Edward *et al*., 2005)**.**

Complementary foods play an important role in child growth and development because it complements both nutritional and developmental needs of the infant when breast milk alone is no longer sufficient for the child (Temesgen *et al*., 2013). Good quality weaning food must have high nutrient, bulk density, low viscosity, and appropriate texture along with high energy, protein, micronutrient contents and consistency that allows easy consumption (Singh *et al*., 2014). Serious public health challenges may occur due to deficient in essential macronutrient and micro nutrients in infant’s food leading malnutrtion like marasmus or kwashiorkor among children especially in developing country (Ayo *et al*., 2011). Protein energy malnutrition (PEM) is the most lethal form of malnutrition commonly prevalent during the crucial transitional phase when children are weaned from breast milk to semi solids or fully adult foods. In view of this nutritional problem, several strategies have been used to formulate weaning food through a combination of locally available food materials that complement each other in such a way as to create a new pattern of essential nutrients that provide the recommended daily allowance for infants. Hence, the need for the study.

MATERIALS AND METHODS

Sorghum grains and Moringa seed were purchased from Kure Ultra Modern Market, Minna, Niger State, Nigeria. All chemicals used were of analytical grade. All analyses were carried out at Food Processing Laboratory, Department of Food Science and Technology, Federal University of Technology, Minna, Niger State.

Sample preparation

Preparation of sorghum starch

Sorghum starch was prepared using the method described by Zubair and Osundahunsi (2016) with slight modification. Five hundred gram (500g) of sorghum was cleaned by winnowing to remove chaffs and other light contaminant, washed in a bucket of water during which the bad seed is floated and skimmed off. The cleaned sorghum is then soaked in a bucket containing distilled water and steeped for 48 h at room temperature. The steep water was discarded and soaked grain drained and thereafter wet-milled using a Kenwood chef grinder. The slurry was then sieved through a muslin cloth to remove the over tails which were discarded. The over tails were further washed off with 600 ml of distilled water. The slurry was allowed to stand for 48h to settle down and to promote the fermentation process at room temperature. The souring water was decanted from the sediments and the fermented slurry obtained was collected into a muslin cloth and hand squeezed to reduce the moisture content in order to facilitate the drying process. The semi-wet slurry was dried at temperature of 60^0C for 8h. The dried slurry is then dry milled and sieved through 250 mm aperture. The resultant starch powder was cooled, packaged in airtight low-density polyethylene bags and stored under ambient condition

Preparation of germinated moringa seed flour

Moringa seeds were processed according to the method described by Ijarotimi *et al.*, (2013) with slight modification. The seeds were sorted, washed and soaked in water for 12 h after which the water was drained and the seeds were spread on perforated trays lined with wet cloth and covered with another wet cloth. The seeds were allowed to germinate (sprout) at room temperature 27 ± 2^0C for a period of 72 h. The germinated seeds were picked carefully with the sprouts, washed, dehulled, oven dried at 80^0C for 9 h using cabinet drier and dry milled. It was then sieved through 250 mm aperture and packaged in airtight containers and stored under ambient condition.

Table1. Blend formulation of sorghum and moringa seed flour

Samples	Sorghum starch (%)	Moringa seed flour (%)
A	100	0
B	97.5	2.5
C	95	5
D	92.5	7.5

Sample analyses

Determination of functional properties

The bulk density of the sample, water and oil absorption capacities, gelation capacity and swelling power were determined by the method described by Onwuka (2005).

Determination of proximate composition

Moisture content, ash content, protein content, fibre content, fat content and carbohydrate content were determined using the method described by AOAC (2019).

Statistical Analysis

All experiments were carried out in triplicate and data obtained were subjected to analysis of variance (ANOVA) and the means were separated by lowest standard deviation test (SPSS version 16). Significant level was accepted at 5%.

RESULTS AND DISCUSSION

Bulk density is as the ratio of flour weight to the volume in gram per mills. The bulk density increases significantly ($p \leq 0.05$) with an increase in the percentage of inclusion of moringa seed flour with the sample having the highest percentage inclusion recording the highest value of 0.63 g/ml and the control sample having the lowest value of 0.57 g/ml. This could be as a result of the fact that moringa seed is rich in fibre as shown in the fibre content of the sample. The value of the bulk density is in agreement with the value of 0.54-0.71 g/ml reported by Lalude *et al*. (2006) for a weaning food from sorghum. The value is also in line with the value range of 0.58-0.61g/ml reported by Jude-ojei *et al*. (2017) for maize-ogi supplemented with fermented moringa seed flour. The bulk density of flour samples influences the amount and strength of packaging material, energy density, texture, and mouth feel (Udensi *et al*., 2006). Nutritionally, low bulk density promotes easy digestibility of food products, particularly among children with immature digestive system (Osundahunsi *et al*., 2002). Swelling capacity of food gives an indication of increase in the volume upon absorption of water. It is very important parameter when changes in volume after processing enhance the acceptability of the final product. The Swelling index recorded a significant decrease ($p \leq 0.05$) as the percentage inclusion of moringa seed flour increases. These observed decrease in the swelling power may be as a result of disruption of hydrogen atom inherent in the seed by amylases and proteases into sugars and amino acids as reported by Egwim *et al*. (2009). A flour product with high swelling capacity has comparative advantages over those with low swelling capacity as the volume of the final product with high swelling capacity is of economic advantage (Onigbogi *et al*., 2006). No significant difference ($P \geq 0.05$) observed in the water absorption capacity of all the samples. Although, the water absorption capacity of the sample with 2.5% inclusion of moringa seed flour shows a higher value than other samples. The result range (1.6 ml/g -1.75 ml/g) is different from the value 4.15g/ml reported by (Simwaka *et al*., 2017) for sorghum starch. This difference could be as a result of processing condition. Water absorption capacity of the control was higher than the other samples except for sample B which has the highest. This result against what was reported by (Simwaka *et al.*, 2017) in water absorption capacity of 4.15ml/g of fermented Sorghum supplemented with amaranth in effect of fermentation on physicochemical and antinutritional factors of complementary foods from millet, sorghum, pumpkin and amaranth seed flours. This could be due to the decrease in amount of carbohydrates (starch) and fibre in this flour. Water absorption index plays an important role in the food preparation as it influences other functional and sensory properties (Sreerama *et al*., 2012). It is a critical function of protein in various food products like soups, dough and baked products (Adeyeye *et al*., 1998). The water absorption capacity of flour is useful in determining the suitability of the material in bakery purposes (Oyebode *et al.*, 2007). Lower water absorption capacity is desirable for making gruels in 47 which more flour can be added per unit volume of the gruel as this will help to increase the energy density and nutrient content of infant food (Singh *et al*., 2012). Oil absorption capacity is an important functional property as it is attributed to the physical entrapment of oil which is considered important as flour retainer and improves the mouth feel of food products (Oyebode *et al.*, 2007). There was no significant difference ($P \geq 0.05$) between an oil absorption capacity of the control sample and the samples with inclusion of moringa seed flour. Although the control sample and the sample with 2.5% moringa seed flour have the highest value. Flour from seeds and legumes that have oil absorption capacity of more than 6.00% have been reported to perform well in the formulation of meat extenders, bakery and weaning products (Yadahally *et al*., 2008). The least gelation capacity of sample with moringa seed flour was found to be significantly ($P \leq 0.05$) higher than the control sample. Least gelation concentration is an index of gelation. According to Olapade *et al*., (2007) gels are characterized by their viscosity, plasticity and elasticity and the higher the least gelation concentration, the lower is the ability of the flour to form a stable gel. The results show that sample B and C formed a stable gel than sample A and control and such product will serves as a good binder and provide consistency in food preparation such as semi-solid beverages like kunun-zaki (Fahey, 2005). The result was in agreement with Jude-ojei *et al*., (2017) that reported value of 5.67-15.33% for maize starch supplemented with fermented moringa Seed flour. However, high least gelation concentration observed in control samples are desirable as Arawande *et al*., (2010) reported that high least gelation concentration will lead to reduction in viscosity which therefore leads to increase in nutrient density and low dietary bulk which is highly favorable for a good weaning diets.

The moisture content of the sample reduces with an increasing quantity of inclusion of moringa seed flour. This is indication that the flour blend can be stored for a longer time without spoilage. Low moisture content in complementary foods is very important to prevent nutrient losses and ensure adequate shelf life of the product as the removal of moisture generally increases concentration of nutrients and make some nutrients more available (Amankwah *et al*., 2009). The range of the moisture content (7.20 to 8.80%) is in line with protein advisory group of United Nation that recommended that moisture content of flour should not exceed 10% in order to keep a floury product for a reasonably long time as reported by Olorunfemi *et al*. (2006). The higher moisture content observed in the control sample was probably due to some variation in processing techniques.

The fat content recorded a significantly (P≤0.05) higher values with an increase in percentage inclusion seed flour than the control sample. This might be due to the fact that moringa seed is an oil seed (Jimoh *et al.*, 2017). High fat content is nutritionally advantageous because it can increase the energy level of a diet, however, it reduce the shelf life and stability of the food product during storage since unsaturated oils are vulnerable to oxidative rancidity (Adebayo *et al*., 2012).

There was no significant difference (P≤0.05) in the fibre content of all the samples. Although, the sample with the highest percentage of inclusion of moringa seed flour (7.5%) recorded the highest value of fibre content (3.20%). The result obtained was in line with the findings of Jimoh *et al*., (2017) that reported a value range of 1.65% to 7.94% for some selected sorghum cultivars. The fibre contents of the samples were also in line with the recommended value of less than 5% specified by the (FSSAI, 2011). Weaning food with low fibre content is very important as this would enable children to consume food that is more nutrient-dense and to meet the daily energy and other vital nutrient requirements (Ijarotimi *et al*., 2013). Children are expected to have lower dietary fiber intakes than adults, with the recommended amount proportional to body weight (Fasasi *et al*., 2009). Possible undesirable aspects of high fiber levels in weaning foods include increased bulk and lower caloric density, irritation of the gut mucosa, and adverse effects on the efficiency of absorption of various nutrients of significance in diets with marginal nutrient content (Ijarotimi *et al.*, 2013). Diet high in fibre content has been reported to impair protein and mineral digestion and absorption in human (Asma *et al*., 2006).

The protein content of all the samples that contain moringa seed flour was significantly higher than the control sample. This might be due to the fact that moringa seed is a good source of protein as reported by Fasasi (2009). The value obtained 6.34% to 12.15% is in the range of not more than 15% recommended by (WHO, 2001). Fasasi, (2009) reported that germination and fermentation improves the protein content and quality of food products. These improvement in protein content during germination of the seeds may be attributed to the net synthesis of enzymic protein by the germinating seeds (Inyang *et al*., 2008). The ash content of the control sample (0.55%) was the lowest while sample B has the highest value of (1.0%). These values are lower than the range of values reported by Mustapha *et al*., (2003) and Abu *et al*., (2001) who reported value range of 1.90% - 1.97% and 1.01% - 1.56% respectively for sorghum starch. The level of ash in food is an important nutritional indicator of minerals density (Lee *et al*., 2007).

The carbohydrates content value range of 66.70%-72.10% agrees with the result 65.15%-76.28% reported by Jimoh *et al.* (2017) for sorghum starch and also fall within the value range of 68.81%-69.65 as reported by Mustapha *et al*. (2003).

Carbohydrate contributes to the bulk of energy of the sample which makes it high energy food and ideal for the growth of growing infants (Ago *et al*., 2004). The calories in an infant diet are provided by the protein, fat and carbohydrate which are major components of complementary foods that help to meet the energy requirement of growing infants and insufficient level of any of these may lead to malnutrition (Ago *et al*., 2004).

Table 2. Functional properties of sorghum and moringa seed flour

Parameters	A	B	C	D
Bulk density (g/ml)	0.57^{c}±0.02	0.61^{ab}±0.01	0.58±0.01	0.63^{a}±0.00
Swelling index (g/g)	9.12^{a}±0.04	8.43^{b}±0.11	8.25^{bc}±0.07	8.06^{c}±0.02
Water absorption capacity (ml/g)	1.70^{a}±0.28	1.75^{a}±0.3	1.60^{a}±.0.28	1.60^{a}±0.28
Oil absorption capacity (ml/g)	1.30^{a}±0.14	1.30^{a}±0.14	1.10^{a}±0.14	1.00^{a}±0.00
Least gelation (%)	10.00^{a}±0.00	9.00^{a}±0.00	8.00^{b}±0.00	8.00^{b}±0.00

Values are mean ± standard deviation of duplicate determination. Mean in the same row followed by different superscript are significantly different (P≤0.05). A= control (100% sorghum starch), B= 97.5% sorghum starch and 2.5% moringa seed flour, C= 95% sorghum starch and 5% moringa seed flour, D = 92.5% sorghum starch and 7.5% moringa seed flour

Table 3. Proximate composition of sorghum and moringa seed flour

Parameters (%)	A	B	C	D
Moisture content	8.80^{a}±0.00	7.50^{b}±0.14	7.30^{bc}±0.14	7.20^{c}±0.00
Fat content	9.25^{b}±1.06	10.25^{b}±0.35	10.75^{ab}±0.35	12.25^{a}±0.35
Fibre content	3.01^{a}±0.08	3.05^{a}±0.06	3.16^{a}±0.85	3.20^{a}±0.11
Protein content	6.34^{d}±0.20	8.70^{c}±0.07	11.28^{b}±0.14	12.15^{a}±0.14
Ash content	0.55^{c}±0.07	1.00^{a}±0.00	0.63^{bc}±0.42	0.69^{c}±0.01
Carbohydrate content	72.10^{a}±0.75	67.64^{b}±0.57	66.76^{b}±0.36	66.70^{b}±0.60

Values are mean ± standard deviation of duplicate determination. Mean in the same row followed by different superscript are significantly different (P≤0.05). A= control (100% sorghum starch), B= 97.5% sorghum starch and 2.5% moringa seed flour, C= 95% sorghum starch and 5% moringa seed flour, D = 92.5% sorghum starch and 7.5% moringa seed flour

CONCLUSION

The study shows that the addition of moringa seed flour to sorghum starch improve the functionality as well as some nutritional characteristics as shown in the protein, fat, ash and fibre content of the sample. Increases in the protein and fat content will help in reducing the incidence of protein energy malnutrition. The moisture content was also found to reduce significantly with addition of moringa seed flour hence, improvement in shelf life stability. Addition of moringa seed flour to staple food is hereby recommended.

REFERENCES

Abu, A.E, Aba, D. A , Chindo, P.S., Ango, K.M. and Maigida, D.N. (2001). Biochemical evaluation of ten sorghum cultivars compared with Wheat for baking characteristics. Institute of Agricultural Research, Zaria

Adebayo, A.O, Olatodoye, O.P, Ogundipe, O.O, Akande, E, Isiah, C.G. (2012). Production and quality evaluation of complementary foods formulated from fermented sorghum, walnut and ginger. *Journal Applied Bioscience.* 54: 3901-3910.

Adeyeye, E. I. and Aye, P.A. (1998). The effect of sample preparation on proximate composition and thefunctional properties of African yam bean flours. Note 1 La Rivista Italiana Della Sostanze Grasse, LXXV Maggio. pp. 253-261

Agu, H.O, Aluyah, E. (2004). Production and chemical analysis of weaning food from maize, Soy bean and fluted pumpkin seed flour. *Nigeria Food Journal*. 22(1): 171-177.

Amankwah, E.A, Barimah, J., Acheampong, R., Addai, L.O., Nnaji, C.O. (2009). Effect of Fermentation and Malting on the Viscosity of Maize-Soyabean weaning blends. *Pakistan Journal Nutrition*. 8(10): 1671-1675.

Anjorin, T.S., Ikokoh, P., Okolo, S. (2010). Mineral composition of *Moringa oleifera* leaves, pods and seeds from two regions in Abuja, Nigeria. *International Journal Agriculture and Biology*. 12: 431-434

AOAC**.** The Official Method of Analysis 21st edn, Association of Official Analytical Chemist, Washington DC, USA, 2019

Arawande, J.O., Borokini, F.B. (2010). Comparative study on chemical composition and functional \ properties of three Nigerian legumes (Jack beans, pigeon pea and cowpea). *Journal Emerging Trends in Engineering Applied Sciences* (JETEAS). 1(1): 89-95.

Ayo, J.A., Oluwalana, I.B., Idowu, M.A., Ikuomola, D.S., Ayo, V.A. (2011). Production and evaluation of millet-egg-soybean hull composite flour: A weaning. *Journal Food Nutrition*. 1(1):7- 13.

Eckhoff, S.R., and Watson, S.A. (2009). Corn and sorghum starches production. In Starch: Chemistry and Technology, 3 ed., J. BeMiller, and RWhistler, Eds. Academic Press:New York

Edward, L., Alexi, T., and Abhi, L. (2005). Protein malnutrition in Swaziland. *J. of Fd., Agric. & Envi*. 3 (2): 81 - 83. Ey

Egwin, E., Adenomon, M. (2009). Predicting α-amylase yield and malt quality of some sprouting \ cereals using 2nd order polynomial model. *Afr J Biochem Res.* 3(8): 288-292.

Fahey, J.W. (2005). *Moringa oleifera*: A review of the medical evidence for its nutritional, Therapeutic and prophylactic properties Part 1. *Tree for Life J.*1 (5): 1-19.

FAO, (2004): United Nations Food and Agriculture Organization. Retrieved from (http://faostat.fao.org).

Fasasi, O.S. (2009). Proximate, Antinutritional factors and functional properties of processed pearl millet (*Pennisetum glaucum)*. Journal Food Technology. 73(3): 92-97.

Ijarotimi, O.S., Adeoti, O. A., Ariyo, O. (2013). Comparative study on nutrient composition, phytochemical, and functional characteristics of raw, germinated, and fermented *Moringa oleifera* seed flour. *Food Science Nutrition*. 1(6): 452-463.

Inyang, C.U., Zakari, K.K. (2008). Effect of germination and fermentation of pearl millet on the proximate, chemical and sensory properties of instant "Fura" a Nigerian cereal food. *Pakistan Journal of Nutrition*. 7(1): 9-12.

Jimoh, W.L.O. and Abdullahi, M.S. (2017). Proximate Analysis of Selected Sorghum Cultivars . *Journal of Pure and Applied Sciences*, 10(1): 285 – 288.

Jude-Ojei, B.S., Ajala 'Lola, Ajayi I.O. and Emmanuel, O.A, Oni, S. S. (2017). Physico-chemical and Sensory Qualities of Maize-Ogi Supplemented with Fermented *Moringa oleifera* Seed. *International Journal of Scientific Engineering and Applied Science*

(IJSEAS) – 3 (7):7-16,

Lalude, L.O., Fashakin, J.B. (2006). Development and Nutritional Assessment of a Weaning Food from Sorghum and Oil–Seeds. *Pakistan Journal of Nutrition*. 5(3): 257-260.

Lee, Y.R., Kim, J.Y., Woo, K.S., Hwang, I.G., Kim, K.H. (2007). Changes in the chemical and functional components of Korean rough rice before and after germination. *Food Science Biotechnology*. 16(6): 1006-1010.

Melaku, U., West, C.E and Habtamu, F. (2005). Content of Zinc, Iron, Calcium and their Absorption Inhibitors in Food Commonly Consumed in Ethiopia. *Journal of Food Composition and Analysis*, 18:803-817.

Mustapha, A.A.G, and Magdi, A.O. (2003). Proximate Composition and Content of Sugars, Amino Acids, and Anti Nutritional Factors of three Sorghum varieties. Agricultural research centre, King Sa'ud University, Pp 5-19

Olapade, A.A., Adetuyi, D.O. (2007). Comparison of different methods of producing bambara (*V. \ Subterranean L. Thou)* flours for preparation of moin moin. *Nigerian Food Journal*. 25(2): 150-\ 157.

Olorunfemi, O.B., Akinyosoye, F.A., Adetuyi, F.C. (2006). Microbial and nutritional evaluation of infant weaning food from mixture of fermented food substrates. *Res Journal Biological Science*. 1(1-4): 20-23.

Onigbogi, I.O., Adesina, A. (2006). Functional properties of cowpea/soybean flour blends for akara \ processing. Proceedings of the 30th Annual conference/general meeting of *Nigeria \ Institute of Food Science and Technology*, Lagos. 77-78.

Onimawo, I.A. and Onofun, A.M. (2003). Some Nutritional Contents and Functional Properties of Sorghum Toasted Soybean Blends." *Nigeria Journal of Food Science,* 22: 18-22.

Osundahunsi, O., Aworh, O.C. (2002). A preliminary study on the use of tempe-based formula as weaning diets in Nigeria. *Plant Food Human Nutrition*. 57(3-4): 365-37.

Oyebode, E.T., Ojo, M.A., Oshodi, A.A. (2007). Physicochemical properties and in-vitro protein digestibility of flour and protein isolates from *Adenopus breviflorus Benth seed. Science Focus. 12(1): 28-34*

Simwaka, J.E., Chamba, M.V.M., Huiming, Z., Masamba, K.G. and Luo, Y. (2017). Effect of fermentation on physicochemical and antinutritional factors of complementary foods from millet sorghum, pumpkin and amaranth seed flours. *International Food Research Journal* 24(5): 1869-1879

Singh, A., Yadav, N. and Sharma, S. (2012). Effect of fermentation on physicochemical properties and invitro starch and protein digestibilities of selected cereals. *International Journal of Agricultural and Food Science* 2(3): 66-70.

Singh (2014). Recent Approaches in Diagnosis and Control of Mycobacterial InfectionsAdvances inAnimal and Veterinary Sciences. 2(1S): 1 – 12 Special Issue – 1 (Infectious Diseases of Animals and Global Health)

Sreerama, Y. N., Sashikala, V. B., Pratape, V. M. and Singh, V. (2012). Nutrients and anti nutrients in cowpeas and horse gram flours in comparison to chickpea flour: Evaluation of their flour functionality. *Food Chemistry* 131(2): 462-468

Temesgen, M. (2013). Nutritional status of Ethiopian weaning and complementary foods: A review. Scientific Report. 2: 1-9.

Udensi, E. A. and Okoronkwo, K. A. (2006). Effect of fermentation and germination on the physicochemical properties of *mucuna cochinchinensis* protein isolate. *African Journal of Biotechnology*. 5:896–900.

WHO (2001). Guiding principles for complementary feeding of the breastfed child. Pan American Health Organization, Washington DC.

Yadahally, N.S, Vadakkot, B.S, Vishwas, M.P. (2008). Expansion properties and ultrastructure of \ legumes: effects of chemical and enzyme pre-treatments. *Food Science Technol*. 42(1): 44-49.

Zubair, A.B and Osundahunsi, O.F (2016). Effect of steeping period on the physicochemical and pasting properties of sorghum starch. *Applied Tropical Agriculture*. 21(3):12-18