Advanced Research Journal of Microbiology (ARJM) ISSN 1718-3499, Vol. 7 (2), pp. 345-250, December, 2021.
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Full Length Research Paper

Micro nutrient deficiency and protein energy malnutrition of African oil bean seed (*Pentaclethra macrophylla* Benth.)

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Accepted 16 February, 2021

The proximate, anti-nutrient and sensory properties of millet *ogi* supplemented with treated African oil bean flour were evaluated. Millet *ogi* was produced using traditional method which involved soaking, wet milling, fermentation and drying. African oil bean seeds were decoated, roasted, fermented and defatted under controlled experiment. Flours obtained were substituted with millet *ogi* at 10 and 20% levels. The results show that there was significant ($P \leq 0.05$) increase in fat, crude protein and energy value and a converse decrease in the carbohydrate content. Fermentation and roasting significantly ($P \leq 0.05$) reduced oxalate and tannin contents of the blends. However, phytate and phytate phosphorus were not significantly ($P \geq 0.05$) affected. In sensory attributes, samples containing fermented African oil bean flour compete favourably with the control while samples having roasted blends had the least acceptability.

Key words: Millet, African oil bean seed, *ogi,* roasting, fermentation.

INTRODUCTION

In order to meet the challenging food need of man, most especially those in the developing countries, various approaches on the use of under utilised locally found foods to supplement the daily staple such as millet, maize, corn, cassava, etc. has been advocated as a measure. To tackle the root cause of malnutrition and hunger in developing world, the introduction of an approach geared towards providing adequate and sufficient nutrition is paramount (FAO, 2013). The basic requirement of man is his right to adequate and sufficient nutrition. Inadequate nutrition early in life and amongst the elderly can result in irremediable damage to the developing brain and body of infants as well as complications in the elderly (Nathan, 2008). In order to have a healthy population sufficiently satisfied with adequate nutrition hence, the need to exploit unexploited and underutilized food resources is essential (Enujiugha and Agbede, 2000).

Ogi is a gruel considered as a special transitional food cherished by infants and is characterised by its homogeneity and its liquid or semi-liquid consistency (Treche, 1998). Cereals grains such as maize, millet, sorghum, etc, are usually utilised locally in *ogi* production due to their

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high gelling capacity, availability, affordability and ease of processing. Millet, a predominantly cross pollinated crop found mostly in the semi-arid tropical region of Asia and Africa, is a starchy cereal crop used in gruel preparation (Rai et al., 1999). Though high in carbohydrate, millet has been found to be a good source of essential amino acids excluding lysine and threonine (Saleh et al., 2013) and phytochemicals and micronutrients (Mal et al., 2010; Singh et al., 2012). It is classified as the principal source of carbohydrate, vitamins and minerals for millions of the poorest people in the semi-arid tropics of Asia and Africa. Furthermore, millet is also used as temporary summer pasture crop and is considered one of the most important cereals in the tropics alongside rice, maize and sorghum (Mal et al., 2010).

Ogi production involves soaking the grains in water for 3 h until soft. Softened grains are then ground in to a slurry and wet-sieved through cheese cloth. The starch is allowed to sediment and ferment in a liquid menstrum (Ojokoh, 2009). Ready to serve *Ogi* is prepared by diluting the starch sediment in little amount of water after which boiling water is added to form an aqueous porridge (Ojokoh, 2009). It is considered a common staple food in most African countries. The product serves different categories of people in terms of its uses, such as weaning food for babies, breakfast cereal for adults, a meal to enhance breast milk production for nursing mothers, and recovery diet for the sick (Afolayan et al., 2009)

African oil bean seed (*Pentaclethra macrophylla* Benth.) is a leguminous woody plant belonging to the subfamily Mimosoideae which occurs naturally in the humid lowlands of west tropical Africa (Enujiugha, 2003). Its fermented form *Ugba* amongst the Igbos, is used for the preparation of many delicious African delicacies including African salad (abacha), soups and sausages for eating with different staples (Enujiugha, 2003). The seed serves as a source of edible oil and the residue after oil extraction is locally used for candles and soap making. African oil bean seed contains essential amino and fatty acids making it a good source of protein and calories (Enujiugha, 2003). It also serves as a good source of vitamin (Enujiugha and Olagundoye, 2001). This protein rich legume has been found to contain sufficient amounts of lysine and tryptophan, lacking in cereals (Ikediobi, 1981) and this unique attribute of the oil seed makes it a suitable and convenient raw material for supplementation to improve the protein quality of cereal-based products.

Despite the nutritive relevance of the African oil bean seed, its high oil content, short shelf life and the presence of antinutrients are some of the reasons limiting its use as a food supplement. Treatments such as soaking, fermentation, roasting, cooking and malting have been found to not only increase the nutritive quality of foods but also reduce antinutritional content (Ajeigbe et al., 2012; Enujiugha and Olagundoye, 2001). Enujiugha (2006) supplemented *ogi* with raw African oil bean seed for infant weaning. The high an-tinutrients found in the resultant gruel serve as its greatest limitation in spite of the increase in the nutrient composition of the blend.

This study therefore was aimed at subjecting African oil bean seed to roasting and fermentation treatments and then blending the treated flour obtained with millet flour. Inclusion of treated African oil bean seed flour in to millet *ogi* would enhance the nutritional composition of the blend most especially, the essential amino acid and fatty acid compositions as well as protein and calorie values. This would address problems of micro nutrient deficiency and protein energy malnutrition.

MATERIALS AND METHODS

Source of material

Millet and African oil bean seeds were purchased from the Kure Ultra-Modern Market Minna, Niger State, Nigeria.

Production of millet flour

Millet flour (MF) was produced using the method described by Enujiugha (2006). The grains were manually cleaned to remove stones and extraneous materials after which they were soaked for 72 h at 25°C. Soaked grains were dehulled and wet milled using laboratory Kenwood blender (Mini-Processor Model A90LD). The resultant slurry was fermented for 24 h at 25°C after which it was dewatered and then oven dried for 4 h at 65°C. The dried fermented flour lumps were broken down and milled into finer flour particles and passed through 0.25 mm sieve.

Production of treated African oil bean seed flour

Method described by Enujiugha and Olagundoye (2001) was adopted with slight modification. African oil bean seeds were manually sorted, cleaned and washed in cold tap water. Washed seeds were parboiled for 4 h and worked in a mortar to dehull the seeds and increase their surface area for easy fermentation and even penetration of heat during roasting. The kernels were then recooked for 5 h and washed in three changes of water, then soaked for 6 h.

Fully soaked kernels were drained and washed again in three changes of water. Washed kernels were then divided into two equal portions (500 g each). One portion was oven dried at 100°C for 90 min and then roasted at 200°C for 90 min. The other portion was subjected to natural fermentation after inoculating for 16 h by spreading the cotyledons on a jute bag and covered with the same material.

The cotyledons were fermented for 72 h at 30°C. At the end of fermentation, the mash was oven dried at 100°C for 90 min. Roasted and fermented kernels were separately milled using a Laboratory Hammer Mill and defatted using Soxhlet extractor. The resultant flour samples were oven dried to eliminate residual solvent and ground into fine flour and passed through 0.25 mm sieve. The two flour samples were packaged inside high density polyethene bag and stored in the refrigerator at 4°C prior to further analysis.

Formulation of blends

Millet and treated African oil bean seed flours were blended at ratios 90:10, 80:20, 90:10 and 80:20% for roasted and fermented

Table 1. Proximate composition of composite flour samples.

Proximate (%)	A	B	C	D	E
Moisture	4.26 ±2.00	4.11^{a} ±2.00	5.89^{a} ±2.00	3.43^{a} ±2.00	4.21 ±2.00
Crude fat	3.26 ±2.00	5.49^{ab} ±2.00	8.64^{a} ±2.00	3.10 ±2.00	4.03^{b} ±2.00
Crude protein	8.32 ±2.00	14.37 ±2.00	12.92 ±2.00	13.45 ±2.00	12.32 ±2.00
Crude fibre	2.27 ±2.00	3.81^{a} ±2.00	4.02^{a} ±2.00	3.52 ±2.00	4.11^{a} ±2.00
Ash	1.07 ±2.00	1.07^{a} ±2.00	1.22^{a} ±2.00	1.31 ±2.00	1.32^{a} ±2.00
Carbohydrate	81.43 ±2.00	71.76 ±2.00	67.93 ±2.00	75.81 ±2.00	74.62 ±2.00
Energy value (Kcal,100g)	388.34^{c} ±2.00	393.75^{b} ±2.00	401.10^{a} ±2.00	384.90^{cd} ±2.00	384.01^{d} ±2.00

Values are means and standard deviations of three determinations. Values not followed by the same superscript in the same row are significantly different (p<0.05). A = 100% millet flour; B = 90% millet flour and 10% roasted African oil bean seed flour; C = 80% millet flour and 20% roasted African oil bean seed flour; D = 90% millet flour and 10% fermented African oil bean seed flour; E = 80% millet flour and 20% fermented African oil bean seed flour.

flours, respectively, with 100% millet flour as the standard. A Kenwood mixer at speed 6 for 5 min was used for mixing flour samples to achieve uniform blending.

Proximate analysis

The moisture content, fat, crude protein, crude fibre, ash and carbohydrate of the flour blends and the control were determined using the method described by AOAC (2000).

Antinutrient determination

Phytin-phosphorus was determined as described by Wheeler and Ferrel (1971). Phytic acid was quantified as described by Aletor and Fasuyi (1997). Total cyanide was analyzed according to the method of AOAC (1990).

Determination of tannin was done according to the method outlined by Makkar et al. (1993). Oxalate content was quantified as described by Oke (1969). Antinutrients were determined in both the control and the blends.

Determination of sensory properties

A thirty-member panel consisting of students and staff of Food Science and Nutrition Option, Department of Animal Production of Federal University of Technology, Minna, Niger State were involved in the sensory evaluation. Ready to serve *Ogi* from various blends and the control were prepared using the traditional method of mixing the flour with a little amount of water and then adding boiling water to the paste until a porridge-like consistency is obtained. After preparation, the porridges were served and presented in coded white plastic plates.

The order of presentation of samples to the panel was randomized. Tap water was provided to rinse the mouth between evaluations. The panellists were instructed to evaluate the coded samples for appearance, texture, aroma, taste, colour and overall acceptability. Each sensory attribute was rated on a 9-point Hedonic scale (1=disliked extremely while 9-liked extremely).

Statistical analysis

Torrie, 1980). The difference between mean values was determined by least significant difference (LSD) and accepted at 5% probability level.

RESULTS AND DISCUSSION

Effect of treatment on proximate composition of millet and African oil bean seed flour blends

Table 1 shows the proximate composition of the flour blends. The result shows that the flour blends and the control were not significantly (p > 0.05) different in moisture content, crude fibre and ash. However, the samples were significantly (p < 0.05) different in crude fat, crude protein, total carbohydrate and energy value.

The fat content of the control (sample A) and blends containing 10 and 20% fermented African oil bean flours (samples B and C) were not significantly (p>0.05) different from each other. However, samples D and E containing 10 and 20% roasted African oil bean flour were signify-cantly (p<0.05) high in fat content. The increase in the fat content of blends with roasted African oil bean flour might be attributed to the contribution of fat globules extracted from the flour matrix during roasting. Unlike the blends that had fermented flour, the low fat content might be due to the utilisation of the available fat by microbes during fermentation. This increase shows a similar trend in roasted unripe plantain, corn and ripe plantain reported by Adetunde et al. (2012). Furthermore, loss of moisture during roasting could concentrate other macro molecules hence, increasing their concentration. From the stand point of storage, blends with high fat will be more susceptible to rancidity.

The protein content of blends containing both fermented and roasted African oil bean flours (samples B, C, D and E) were found to be significantly (p < 0.05) high. Fermentation and roasting both have beneficial effects on Data obtained were analysed using one way ANOVA (Steel and protein digestibility. The complex peptides were

Table 2. Anti-nutrient composition of flour composite.

Anti-nutrient (%)	A	B	C	D	E
Phytate	20.14 ±2.00	25.20 ±2.00	22.92 ±2.00	22.85 ±2.00	21.71 ±2.00
Oxalate	22.50 ±2.00	15.96 ±2.00	17.94 ±2.00	17.92 ±2.00	16.35 ±2.00
Tannin	220.00 ±2.00	185.00 ±2.00	160.00 ±2.00	181.00 ±2.00	152.50 ±2.00
Cyanide	6.99 ±2.00	14.41 ±2.00	20.52 ±2.00	11.35 ±2.00	23.58 ±2.00
Phytate phosphorus	5.52^{a}±2.00	7.18^{a}±2.00	6.28^{a}±2.00	6.26^{a}±2.00	6.05^{a}±2.00

Values are means and standard deviations of three determinations. Values not followed by the same superscript in the same row are significantly different at ($p < 0.05$). A = 100% millet flour; B = 90% millet flour and 10% roasted African oil bean seed flour; C = 80% millet flour and 20% roasted African oil bean seed flour; D = 90% millet flour and 10% fermented African oil bean seed flour; E = 80% millet flour and 20% fermented African oil bean seed flour.

broken down to low molecular weights and constituent amino acids thereby increasing the active sites for protease activities during digestion (James and Nwabueze, 2013a). There was a significant ($p < 0.05$) reduction in the carbo-hydrate content of flour blends containing treated African oil bean flour at different ratios with sample E which contains 20% roasted flour having the lowest value (67.93%). This result agreed with report by Enujiugha (2006). The reduction could be attributed to the replacement of millet flour (carbohydrate source) with treated African oil bean flour at different ratios. Also, action of micro-organisms which degrade starch into sugars during fermentation could cause an increase in sugar content and a decrease in starch level (Huang and Zhang, 2011). This degradation would improve the nutritive value and further enhance absorption and digestibility of the gruel produced.

Roasting brought about significant ($p < 0.05$) increase in energy values with sample E having the highest increase (401 Kcal). This shows that roasting African oil bean flour and 20% level of substitution had the highest energy value. It could be suggested that roasting being a heat process could results in increase concentration of certain nutrients.

Effect of treatment on antinutrients in millet and African oil bean seed flour

The antinutrient composition of the control and the blends is shown in Table 2. The result shows that fermentation, roasting and replacement of millet at 10 and 20% were not significantly ($p > 0.05$) affected the phytate and phytate phosphorus content of all the samples. The oxalate contents of blends containing fermented and roasted African oil bean flour at different replacement levels were found to be significantly ($p<0.05$) low. This shows that fermentation and roasting the African oil bean flour have the potency in bringing down the oxalate content of the blends at replacement levels used. This is in line with the research conducted by Enujiugha and Olagundoye (2001) who reported that fermentation and roasting reduced the phytate content of African oil bean. Oxalate in the body combines with divalent cations Ca^{++}, Fe^{++}, forming their insoluble salts. These insoluble salts obstruct kidney tubules leading to kidney stones (Coe, 2005). Hence, it reduction implies increase mineral bioavailability and reduction of renal dysfunction. The high oxalate content in the raw millet flour (22.50%) agreed with report by Enujiugha (2006). Leaching out of phytate present in the outer (aleurone) layer of seeds during soaking brings about phytate reduction. Phytic acid forms insoluble complex with certain trace elements, zinc, iron and copper. The complex formed reduces the mineral bioavailability which in turn deplete tune over of haemoglobin production and impair metabolic process (James and Nwabueze, 2013b). There was significant ($p < 0.05$) decrease in tannin content of blends at different substitution levels. This shows that application of heat during roasting and activities of microbes during fermen-tation of African oil bean flour have reducing effect on tannin. The result is in line with that of Vadivel et al. (2010) who reported that fermentation of soybean brings about breakdown and decrease in tannin content. Reduced tannin content in the blends means increased bioavailability of macromolecules notably, proteins; increased palatability; reduced pathogenesis of cancer development and reduced damage to intestinal tract (Makkar and Becker, 1996; Uzeochina, 2007). The cyanide content of the control was found to be signify-cantly ($p < 0.05$) low as compared to the blends containing treated African oil bean seed flour. It was observed that, blends containing 20% treated African oil bean seed flour were found to be significantly ($p < 0.05$) high in cyanide. This means that, treated African oil bean seed flour has high cyanide content hence, its inclusion at 10% level is preferable.

Sensory attributes of prepared *ogi* from different flour blends

The sensory properties of porridge prepared form the control and different blends are shown in Table 3. The result shows that all the samples were significantly ($p < 0.05$) different in the attributes measured (favour,

Table 3. Sensory attributes of composite flours.

Sensory property	A	B	C	D	E
Flavour	8.73 ±2.00	7.58 ^{a} ±2.00	5.73^{ab} ±2.00	3.77 ±2.00	2.88 ±2.00
Colour	8.59^{a} ±2.0	7.62 ^{a} ±2.00	5.81^{ab} ±2.00	3.31 ±2.00	2.87 ±2.00
Mouth feel	8.31^{a} ±2.0	7.27 ^{a} ±2.00	5.46 ^{ab} ±2.00	3.35 ±2.00	2.88 ±2.00
Texture	8.31^{a} ±2.0	7.19 ^{a} ±2.00	5.62^{ab} ±2.00	3.15 ±2.00	2.91 ±2.00
Taste	8.69^{a} ±2.0	7.69 ^{a} ±2.00	5.96^{ab} ±2.00	3.62 ±2.00	3.23 ±2.00
Overall acceptance	8.36^{a} ±2.0	7.35 ^{a} ±2.00	5.65^{ab} ±2.00	3.54 ±2.00	2.92 ±2.00

Values are means and standard deviations of three determinations. Values not followed by the same superscript in the same row are significantly different ($p<0.05$). A = 100% millet flour; B = 90% millet flour and 10% roasted African oil bean seed flour C = 80% millet flour and 20% roasted African oil bean seed flour; D = 90% millet flour and 10% fermented African oil bean seed flour; E = 80% millet flour and 20% fermented African oil bean seed flour.

appearance, mouth feel, taste, texture and overall acceptability). Blends containing fermented African oil bean flour compete favourably with the control in all the sensory attributes measured.

Samples A, B and C were found to be more acceptable in all parameters of sensory properties analysed. However, samples D and E which contained 10 and 20% roasted African oil bean flour were significantly ($p < 0.05$) low.

This might be possibly as a result of roasting which could have impacted unpleasant characteristic attributes. Omemu (2011) reported that supplementation of fermented cereal gruel with protein-rich food in a bid to upgrade their nutrient composition sometimes bring about undesir-able sensory properties when substituted with cereal. The acceptability of the flour blend with 10 and 20% in cooperation with fermented African oil bean were better preferred by the test panellists.

Conclusion

Inclusion of treated African oil bean flour significantly increased the crude fat, crude protein and energy values of the blends. However, moisture content and crude fibre were not significantly affected. Replacement of millet with treated African oil bean flour was significantly reduced, and tannin contents of the blends and phytate and phytate phosphorus were not significantly affected. Blends con-taining fermented African oil bean flour had superiority in proximate, antinutrients and sensory property over the control and the blends containing roasted African oil bean flour.

Conflict of interest

The authors did not declare any conflict of interest.

REFERENCES

AOAC (1990). Official methods of analysis. 15th Ed., Association of Official Analytical Chemists, Arlington, U.S.A.

AOAC (2000). Official methods of Analysis. Association of Official

AO, Silva BO, Olayinka KO, Alo BI (2012). Effects of roasting on the proximate composition and levels of polycyclic aromatic hydrocarbon in some roasted Nigerian delicacies. J. Emerging trends Eng. Appl. Sci. 3(5):857-862.

Afolayan MO, Afolayan M, Abuah JN (2009). An Investigation into Sorghum Based *Ogi* (ogi-baba) storage characteristics. Adv. J. Food Sci. Technol. 2(1):72-78.

Ajeigbe SO, Mohammed AK, Yahaya IA, Oyelowo AO (2012). Effect of Processing Techniques on Levels of minerals and Antinutritional factors of *Canavalia ensiformis*. Pak. J. Nutr. 11(12):1121-1124.

Aletor VA, Fasuyi O (1997). Nutrient composition and processing effects on cassava leaf (*Manihot esculenta*, Cranzt.) antinutrients. Proceeding of the 2nd Annual Conference of Animal Science Association of Nigeria. Pp.231-242.

Enujiugha VN (2003). Nutrition Changes During Fermentation of African Oil Bean (*Pentaclethra macrophylla* Benth) seeds. Pak. J. Nutr., 2(5):320-323.

Enujiugha VN (2006). Supplementation of *ogi*, a maize-based infant weaning food, with African oil bean (*Pentaclethra macrophylla* Benth). Inter. J. Postharvest Technol. Innovation, 1(2):202-211.

Enujiugha, VN, Agbede JO (2000). Nutritional and Anti-nutritional Characteristics of African Oil Bean (*Pentaclethra macrophylla* Benth) seeds. Appl. Trop. Agric. 5(1):11-14.

Enujiugha VN, Olagundoye TV (2001). Comparative nutritional characteristics of raw fermented and roasted African Oil bean (*Pentaclethra macrophylla* Benth) seeds. La rivista italiana delle sostanze grasse - Vol. LXXVII.

FAO (2013). Guidance Note: Integrating the Right to Adequate Food into Food and Nutrition Security Programmes.

Huang M, Zhang S (2011). Starch degradation and nutrition value improvement in corn grits by solid state fermentation technique with *Coriolus versicolor. Brazilian J.Microbiol.,* 42:1343-1348.

Ikediobi CO (1981). Amino and fatty acid composition of *Pentaclethra macrophylla* Benth and *Treculia Africana*. J. Amer. Oil Chem. Soc. 58(1):30-31.

James S, Nwabueze TU (2013a). Effect of extrusion condition and defatted soybean inclusion on the physico-chemical, Invitro digestibility and sensory acceptability of African breadfruit (*Treculia africana*) blends. Inter. J. Sci. Technol. Res. 2(9):207-211.

James S, Nwabueze TU (2013b). Quality Evaluation of

Extruded Full Fat Blend of African Breadfruit-Soybean-Corn Snack. Inter. J. Sci. Technol. Res. 2(9):212-216.

Makkar HPS, Becker K (1996). Effects of pH, temperature and time on inactivation of tannin and possible implication in detanification studies. J. Agric. Food Chem. 44:1291-1295.

Makkar HPS, Blummed MB, Becken NK (1993). Determination of tannins and their correlation with chemical and protein precipitation method. J. Food Sci. Agric., 61:161-185.

Mal B, Padulosi S, Ravi SB (2010). Minor millets in South Asia: learnings from IFAD-NUS Project in India and Nepal. Maccarese, Rome, Italy: Bioversity Intl and Chennai, India: M.S. Swaminathan Res. Found. pp. 1-185.

Nathan R (2008). Realising children's rights to adequate nutrition Analytical Chemist, 16 edition. Adetunde OT, Oluseyi TO, Oyeyiola through national legislature reform- a report.

Ojokoh AO (2009). A comparative study on the effect of traditional and improved methods of fermentation in the production of *ogi* food. Oriental. J. Chem. 25(3):471-476.

Oke OL (1969). Oxalic acid and plants in animal nutrition. World Rev. n Nutr. Diet, 10:262-303.

Omemu AM (2011). Fermentation dynamics during production of *ogi*, a Nigerian fermented cereal porridge. *Report and opinion,* 3(4):8-17.

Rai KN, Murty DS, Andrews DJ, Bramel-cox PJ (1998). Genetic enhancement of pearl millet and sorghum for the semi-arid tropics of Asia and Africa. Genome, 42:617-628.

Saleh ASM, Zhang Q, Chen J, Shen Q (2013). Millet Grains: Nutritional Quality, Processing, and Potential Health Benefits. Comprehensive Reviews in Food Science and Food Safety, 12:281-295.

Singh KP, Mishra A, Mishra HN (2012). Fuzzy analysis of sensory attributes of bread prepared from millet-based composite flours. Food Sci. Technol. 48:276-82.

Steel RDG, Torrie JH (1980). Principle and Procedures of Statistics. A Biometrical Approach. 2nd edition. McGraw Hill Co. New York, p. 623.

Treche S (1998). Factors affecting the energy intake from gruel by breast–fed Children in developing countries. International Conference on infant and pre-school child nutrition, Ibadan, Nigeria.

Uzeochina OB (2007). Evaluation of the effect of processing techniques on the nutrient and antinutrients contents of Pigeon pea (Cajanus cajan) Seed flours. J. Food Sci. 28:76-77.

Vadivel V, Doss A, Pugalenthi M (2010). Evaluation of nutritional value and protein quality of raw and differentially processed sword bean (*Canavalia gladiata*) seeds. Afri. J. Food Agric. Nutr. and Dev, 10(7):1684-5374.

Wheeler EL, Ferrel RE (1971). A method for phytic acid determination in wheat fractions. Cereal Chem. 48:312-316.