Production of Biscuits from Different Sorghum Varieties Essay Digestibility Protein to Weanling Rats

[1]Maha A. Hejazi and [2]Fizah Mosaed Mohamad Al-Subhi

[1]Faculty of Home Economics - King Abd El-Aziz Univ., Saudi Arabia
[2]Nutrition and Food Sci. Dept., Umm Al-Qura Univ., Saudi Arabia
baby1_248088@yahoo.com

Abstract: The current study was carried out to remove the antinutrition factors associated with sorghum grain and improvement the protein digestibility and bioavailability of iron and zinc using soaking and germination methods. Three sorghum varieties (Giza-15, Ajakss and Giza-114) were subjected to chemical, in vitro, technological and biological evaluation. The results showed that the sorghum varieties after treatments, the antinutrition factors were decreased. Whereas, in vitro biological evaluation protein digestibility was significantly increased for Giza-15 after soaking (69.51g/100g) and germination (78.91g/100g) than Giza-15 raw material (53.19g/100g) followed by Ajakss and Giza-114, respectively. Also, the bioavailability of zinc and iron in sorghum varieties after treatments were paralleled the protein digestibility. Regarding, technological evaluation, biscuits from sorghum varieties, the results showed that when added sorghum varieties after treatments to wheat (72% extraction) at level 1:1 (w/w), the overall acceptability were significant increased than sorghum raw materials and the sorghum germination varieties improvement the quality of biscuits. The results concerning the biological evaluation showed that the gain body weight, food intake and feed efficiency ratio were slightly decreased in rats were fed in biscuits made from sorghum germination followed by soaking treatment and raw sorghum varieties than control rats fed on biscuits made from wheat. Moreover, the results from protein intake, protein efficiency ratio and biological value were occurred the obvious results. From the results, it may be recommended that sorghum varieties after germination were reduced in antinutrition factors and increased in protein digestibility and bioavailability of iron and zinc, gave biscuits high quality and the best results during biological evaluation.

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1. Introduction

Sorghum bicolor L. Monech is the fifth important cereal crop after wheat, rice, maize and barley in terms of production **(FAO, 2005).** The total world annual sorghum production is over 60 millions tons from a cultivated area of 46 millions ha. Sorghum is particularly adapted to drought prone areas hot, semi-arid tropical environments with 400 - 600 mm rain fall – areas that are too dry for other cereals. The sorghum genome is currently sequenced **(Paterson et al. 2003).**

The nutrient composition of sorghum indicates that it is good source of energy, proteins, carbohydrates, vitamins and minerals including the trace elements, particularly iron and zinc, except calcium. Sorghum grains contained minerals such as phosphorus, potassium and magnesium in varying qualities **(Serna – Saldiver and Rooney, 1995).**

Phenolic sorghum phytochemicals are important for human nutrition **(Awika et al. 2004)**. Phenolic compounds are the most widely distributed secondary metabolites, ubiquitously present in the plant kingdom. Among cereals, sorghum has the highest content of phenolic compounds reaching up to 6% (w/w) in some varieties **(Dicko et al. 2005)**. Moreover, phenolic compounds, to getter with other natural compounds scavenge free radicals (antioxidant activity). Interestingly, independent of germination, sorghum grains display high antioxidant activities related to their phenolic content **(Dicko et al. 2005)**.

Sorghum nutritional quality is dictated mainly by chemical composition and the presence of antinutritional factors, such as phytic acid. The effects of phytic acid in human and animal nutrition are related to the interaction of phytic acid with proteins, vitamins and several minerals, and restrict their bioavailability **(Elkhalil et al. 2001).** Therefore, germination induces the synthesis of hydrolytic enzymes e.g. starch degrading enzymes and proteases. The reduction of phytic acid, some flavonoids, and proanthocyanidins has been observed during germination **(Traore et al. 2004)**. The breakdown of protease resistant prolamins (**Mazhar and Chandrasker, 1993)** and increase of the availability of minerals (iron, zinc, etc.) and essential amino acids (principally lysine, tryptophane and methionine) upon germination has also been reported **(Anglani, 1998)**. Germination of sorghum is important for the preparation of weaning foods with low paste viscosity and high energy density **(Malleshi and Desikachar, 1988).** While germination usually has positive aspects, it is important to note that it increase the content of nitrilosodes (cyanogenetic B-glucosides, e.g. dhurrin) of grain **(Traore et al. 2004)**.

Sorghum alone is not considered as a bread making cereal because of the lack of gluten, but addition of 20 -50 % sorghum flour to wheat produces excellent bread **(Hugo, 2000 and 2003).** Among interesting features of sorghum utilization is biscuits and other cooked products **(Olatunji et al. 1989).**

The aim of this investigation was eliminate of antinutritional factors by different methods soaking, and germination to increase protein digestibility and bioavilabilty of iron and zinc. Biscuits product from sorghum and wheat (extraction 72%) at level 1:1 (w/w) was evaluated using sensory evaluation and biological investigation in weanling rats.

2. Materials and Methods

Materials:

Sorghum varieties (Sorghum bicolor L. Moench) , names Giza -15, Ajakss and Giza -114 were brought from Field Crops Research Institute, Agricultural Research Center, Giza- Egypt.

Wheat flour (72 % extraction) was purchased from South Mills Company, Giza – Egypt. Whereas, sugar, butter, milk powder and vanilla were obtained from local market, Giza –Egypt.

Methods:

Treatments of sorghum varieties:

Sorghum varieties were steeped in distilled water in the dark at 20 -25 ^{o} C for 16 h at ratio 1:5 (w/ v) then the grains were dried in an electric oven at 50 ± 5^{o} C according to **Dicko et al. (2002).**

Germination after soaked sorghum varieties were performed at 27±2 ^{o} C for 72 h., the appearance of primary shoots and roots was observed in all of the varieties at the end of germination according to **Dicko et al. (2002)**. Germinated and steeped sorghum grains were dried, ground and storied at -20 ^{o} C until analysis according to **Subramanian et al. (1992).**

Determination of ant nutrition factors in sorghum varieties:

Tannins were determined in sorghum varieties after and before treatment using vanillin hydrochloric acid method as described by **price et al. (1978).** Also, total phenols were determined in sorghum varieties using Folin-Ciocalteu reagent as described by **Singleton and Rossi (1965).** Total flavonoides were determined according to the methods of **Zhishen et al. (1999).** Moreover, Phytate content was determined in defatted sorghum varieties according to the procedure described by **Camire and Clydedole (1982)** and modified by **Mohamed et al. (1986).**

Determination of protein digestibility and bioavailability of iron and zinc:

Protein digestibility in vitro was extracted in sorghum varieties according to **Akeson and Stahmanna (1964).** The digestibility of protein in the supernatant was estimated using Kjeldahl method according to **AOAC (2005).**

The enzymatic degradation of the in vitro digestion to determine the availability of iron and zinc were described by **kiers et al. (2000).** Iron and zinc content was measured using Perkin Elmer (Model 3300, USA) Atomic Absorption Spectrophotometer.

Preparation of biscuits from sorghum varieties:

Biscuit samples were prepared with 50 g. from sorghum varieties and 50 g wheat flour (72% extraction) and also, fat, sugar, milk powder, ammonium carbonate and vanilla were added. The biscuit samples were baked at 170-180 ^{o} C for 20 min according to **Omobuwajo (2003).** The biscuit samples were organolyptically evaluated according to **larmond (1977).**

Biological experiment:

Male albino weanling rats (60 rats) weight 45-65 g was obtained Nutrition Institute at Cairo - Egypt. Animals were housed in individual cages with screen bottoms and fed basal diet for eight days. This diet consisted of corn starch 70 %, casein 15 % corn oil, salts mixture 4 %, vitamin mixture 1 % and cellulose 5 % according to **AOAC (2005)**. After feeding on basal diet rats were divided into ten groups (6 rats for each average 55 g per group). The first group was fed on basal diet considered as control. From the second group to ten groups were fed on basal diet fortified with 20 % biscuit made from sorghum varieties after and before treatment during four weeks (30 days). Each rat was weighted every two days and the food consumption was calculated. At the end of experimental period (30 days), the protein efficiency ratio (PER) was assayed according to **Campbell (1961**) the biological value was calculated according to the equation of **Mitchell and Block (1964).**

B.V. = 49.9 + (16.53 x PER)

Statistical analysis:

Statistical analysis was carried out according **Fisher (1970).** Least squares difference (LSD) test was used to compare the significant difference between means of treatment **(Waller and Duncan, 19691).**

3. Results and Discussion

Antinutritional factors in sorghum varieties:

Table (1) exhibits the phyate content, total phenolic acids, total flavonoids and tannins content of sorghum varieties at different treatments. Phyate content, total phenolic acids, total flavonoids and tannins content in raw sorghum ranged from 557.62 to 6o5.13, 109.78 to 112.01, 43.97 to 57.31 and 1.21 to 2.98 mg/100g, respectively. Sorghum varieties after soaking and germination, the antinutrition factors were significant decreased. This means the soaking and germination for sorghum varieties may be the water soluble of some antinutritional factors. These results are in agreement of **Akilloglu and karakaya (2010) and Nwosu (2010**) who reported that this reduction was expected as soaking in the removal the soluble antinutrients like tannins. From the results, it could be noticed that after soaking and germination the antinutrition factors for all sorghum varieties ware significant decreased. **Claver et al. (2010)** reported that during sorghum seed is steeped in water which may decrease some water soluble nutrients, including tannin.

Table (1): Antinutrition factors of sorghum varieties at different treatments (mg /100g dry weight basis).

Sorghum varieties	Phyate content	Total phenolic acids	Total flavonoids	Tannins content
Raw materials				
Giza- 15	557.63	110.31	55.70	2.71
	± 5.73[c]	± 2.89[b]	± 0.98[b]	± 0.25[a]
Ajakss	607.18	117.50	59.74	1.40
	± 4.74[a]	± 2.45[a]	± 1.64[a]	± 0.21[fg]
Giza - 114	593.11	111.63	46.83	2.01
	± 4.51[b]	± 2.07[b]	± 2.87[c]	± 6.27[f]
Soaking				
Giza - 15	426.37	62.25	40.25	2.05
	± 3.91[d]	± 2.13[de]	± 2.75[d]	± 0.48[b]
Ajakss	410.82	71.05	46.81	1.30
	±5.81[g]	± 1.97[c]	± 3.19[c]	± 0.22[fg]
Giza -114	427.81	72.53	34.79	1.72
	± 4.40[d]	± 2.71[c]	± 3.20[e]	± 0.19[fg]
Germination				
Giza .15	418.74	46.80	29.61	1.27
	± 3.41[de]	± 3.91 h	± 2.54 g	± 0.42[c]
Ajakss	391.21	60.25	28.01	0.89
	± 3.93[g]	± 1.54[d]	± 0.61 g	± 0.27[fg]
Giza-114	422.23	56.89	30.18	1.44
	± 3.95 [ef]	4±.71[ef]	± 2.17 f	± 0.28[fg]
LSD at 5%	5.3521	4.4113	3.8134	1.1199

In vitro protein digestibility and bioavailabity iron and zinc of sorghum varieties after treatments (g/100g):

Data in Table (2) indicated that in vitro protein digestibility and bioavailability iron and zinc of sorghum varieties after soaking and germination. The results reported that protein digestibility of raw sorghum was lowed in Giza- 15, Ajakss and Giza-114 varieties (53.19, 52.31and 51.95%, respectively). The relatively low protein digestibility may be attributed to the influence of antinutrients such as enzyme inhibitors, tannins and phytates which inhibits protein digestion and also due to presence of protein structures that resist digestion (**Urooj, 2011).** Soaking and germination significantly increased the protein digestibility of all varieties compared to the untreatment sorghum. These increases in soaking and germination sorghum varieties can be attributed to an increase in soluble proteins due to partial hydrolysis of strong proteins by endogenous proteases produced during soaking and germination process **(Bhise et al., 1988).**

From the same table showed that the in vitro iron (Fe) and zinc (Zn) bioavailability of sorghum varieties. The results indicated that the bioavailability of Fe and Zn were increased by soaking and the highest in germination for iron in all varieties than zinc bioavailability. **Hurrell et al. (2003)** showed that iron absorption in humans was improved after dephytinisation of tannin- free sorghum grules but not in tannin sorghum gruels, which appeared to due to the strong inhibitory effect of polyphynolic compounds.

Table (2): In vitro protein digestibility and bioavailability iron and zinc of sorghum varieties after soaking and germination (g/100g).

Sorghum treatments	Protein digestibility	Bioavailability	
		Iron	Zinc
Raw materials			
Giza - 15	53.19 ± 3.16[e]	14.17± 0.73[d]	10.74 ± 2.87[d]
Ajakss	52.31± 1.44[e]	9.02± 1.12[f]	9.8 ± 0.12[e]
Giza - 114	51.95± 1.01[e]	10.08± 0.93[f]	8.53 ±1.37[f]
Soaking			
Giza - 15	69.51± 2.91[b]	18.9± 0.19[c]	11.85 ±1.12[c]
Ajakss	67.82± 2.73[b]	11.87± 0.15[f]	10.18± 0.52[d]
Giza -114	63.67± 2.23[c]	13.82 ± 1.22[e]	11.72± 2.19[c]
Germination			
Giza-15	78.91± 2.51[a]	21.73 ± 2.94[a]	18.01± 0.33[a]
Ajakss	70.23 ± 1.91[b]	17.38± 2.37[bc]	18.30 ±1.07[a]
Giza - 114	65.51 ± 2.39[c]	19.38± 0.37[b]	13.16 ±0.81[b]
LSD at 5%	3.1982	2:4127	2.4172

Organoleptic characteristics of biscuits made from sorghum:

Table (3) presents the organaleptic properties of biscuits made from wheat (72% extraction) and sorghum varieties at level 1:1 (W/W). From the results it could be notice that the biscuits from raw sorghum varieties were the lowest in all properties and overall acceptability compared with other treatment sorghum. Biscuits from soaking sorghum varieties were lower in the characteristics biscuits than the varieties germination sorghum was the highest in all properties. These means the biscuits made from wheat (control) was affected by the presence of sorghum as a raw, which lead to decrease in overall acceptability. Moreover, the biscuits from germination sorghum varieties were the best in odor, color, taste, texture and the overall acceptability was Giza-15 gave 93.8% followed by Ajakss 90.9% and Giza-114 gave 90.4%, respectively. These means germination sorghum had reduced antinutiration factors and essay protein digestibility and bioavailability of iron and zinc, therefore to lead a biscuits high quality. **Elkhalil and El-Tinay (2002)** mentioned that the overall quality of the biscuits was reduced by addition of sorghum flour. Moreover, sorghum flour could be utilized for making acceptable quality biscuits up to 50% level. Textural properties of biscuits are one of the most important quality parameter, which affect the demand for biscuits as found by **Mridula et al. (2007).**

Biological experimental:

Sixty rats were fed on basal diet for eight days and they were fed separately on the diet fortification with 20% biscuits made from different sorghum varieties. The experiments were conducted for 30 days and the results are recorded in Tables 4 and 5.

The results concerning the gain body weight, food intake and feed efficiency ratio at the end of experiment were recorded in Table (4). The results showed that in case of rats fed on diet contained 20% biscuits made from germinated sorghum, the gain body weight was slightly decreased from 68.0g in control to 64.0, 60.0 and 59.5g in Giza – 15, Ajakss and Giza – 114 fallowed by soaking sorghum. This decrease in gain body weight is partially due to the degradation in the starch content during soaking and germination sorghum. The decrease of food intake may be due to the presence of relatively high content of sorghum components during soaking and germination the results from feed efficiency ratio was occurred the results from gain body weight and food intake.

Table (3) Organoleptic properties of biscuits from varieties:

Sorghum treatments	Appearance 20	Color 20	Texture 20	Odor 20	Taste 20	Overall acceptability 100
Control	19.12 ±1.52^{a}	19.01 ±0.84^{a}	19.60 ±0.71^{a}	19.60 ±0.84^{a}	19.55 ±0.52^{a}	96.88 ±2.54^{a}
Raw materials						
Giza - 15	17.45 ±1.54^{bc}	17.20 ±2.12^{bc}	17.40 ±1.42^{bc}	18.00 ±1.73^{ab}	15.70 ±1.73^{c}	85.75 ±6.71 ^{c}
Ajakss	17.00 ±2.10^{bc}	17.20 ±2.12^{bc}	16.25 ± 2.15^{bc}	17.70 ± 2.4^{bc}	15.45 ±1.87^{c}	84.50 ±8.51 ^{c}
Giza - 114	16.50 ± 2.15^{c}	16.70 ±1.51^{c}	16.70 ± 1.67 ^{c}	18.30 ±1.45^{ab}	15.30 ±2.33^{c}	83.5 ±7.32 ^{c}
Soaking						
Giza-114	18.55 ± 1.70 ^{ab}	18.25 ± 1.40^{ab}	18.10 ±0.78^{ab}	18.50 ± 1.32^{ab}	17.55 ±1.42^{b}	90.40 ±5.74^{ab}
Ajakss	17.80 ±1.42^{ab}	17.90 ±1.45^{abc}	18.30 ±0.81^{ab}	19.20 ±1.01^{a}	17.70 ±1.51^{b}	90.90 ±4.72^{ab}
Giza - 15	18.20 ± 2.05^{b}	18.70 ± 1.62^{ab}	18.45 ±1.21^{ab}	19.25 ± 1.02^{a}	17.70 ±1.17^{b}	92.30 ± 6.21^{ab}
Germination						
Giza - 15	18.50 ±1.24^{ab}	18.70 ±0.72^{ab}	18.90 ±1.01^{ab}	19.30 ±0.73^{a}	18.40 ±1.53^{ab}	93.80 ±3.92^{b}
Ajkss	18.40 ± 1.21^{ab}	18.45 ±0.11^{ab}	18.25 ±1.32^{ab}	19.60 ±1.18^{a}	17.35 ±2.04^{b}	91.45 ±5.73^{ab}
Giza - 114	18.10 ±1.75^{ab}	18.40 ±0.58^{ab}	18.45 ±0.41^{ab}	18.65 ±1.14^{ab}	17.301 ±.47^{b}	90.90 ±6.43^{ab}
LSD at 5%	1.5715	1.5401	1.4214	1.4267	1.5081	6.1723

Table (4) Means of gain body weight, food intake and feed efficiency in rats fed on biscuits.

Groups	Initial body weight	Gain body weight	Food intake	Feed efficiency ratio
Control	55.28± 4.82^{b}	68.0± 6.35^{a}	320± 21.64^{a}	21.25± 3.67^{a}
Raw materials Giza -15	55.17± 5.15^{b}	52.0± 5.04^{f}	292± 15.12 ^{c}	17.81 ±1.15^{b}
Ajakss	56.12 ±4.71^{a}	51.0 ±5.08^{f}	290 ±13.49 ^{c}	17.59 ±1.18^{b}
Gi2a - 114	54.30± 4.63c	51.0±3.46 f	290±13.72 c	17.59± 1.13b
Soaking Giza - 15	54.10 ±7.29^{c}	57.0±5.61^{d}	308 ±17.54 ^{b}	18.51± 1.45^{c}
Ajakss	55.50± 5.65^{b}	56.0 ±4.24^{d}	305 ±15.31 ^{b}	18.36±1.72^{c}
Giza – 114	54.18± 5.75^{c}	54.0± 3.09^{e}	303± 14.72 ^{b}	17.82^{b}± 1.53
Germination Giza -15	56.20± 5.32^{a}	64.0± 5.72^{a}	315± 20.75 ^{a}	20.32 ±2.15^{a}
Ajakss	55.15± 4.63^{b}	60.0±5.02^{b}	312 ±19.02 ^{a}	19.23± 2.01^{b}
Giza – 114	54.27± 5.32^{c}	59.0± 4.15^{c}	310±19.15 ^{a}	19.03±1.98^{b}
L S D at 5%	5.904	5.934	10.630	0.0015

From the results presented in Table (5) it could be noticed that that the protein intake, protein efficiency ratio and biological value were paralleled to the results from gain body weight, food intake and feed efficiency ratio for sorghum varieties.

From the obvious results it may be recommended that the sorghum germination varieties were decreased in antinutrition factors and significantly increased in protein digestibility and bioavailability iron and zinc. Moreover, the biscuits from soaking sorghum varieties were increased and sorghum germination had biscuits high quality in overall acceptability. Whereas, the biological experimental gave the best results using germination biscuits in gain body weight , food intake , protein intake , protein efficiency ratio and biological value.

Table (5) Means of protein intake, protein efficiency ratio (PER) and biological value (BV) in rats:

Groups	Protein intake	P.E.R*	B.V.**
Control	32.0± 4.96[a]	2.13± 0.357[a]	72.33± 3.76[a]
Raw materials			
Giza - 15	29.2±2.12[c]	1.78± 0.201[d]	68.64± 2.01[c]
Ajakss	29.0±3.15[c]	1.76 ±0.104[d]	68.43±1.59[c]
Giza - 114	290 ±7.78[c]	1.76± 0.371[d]	68.43± 3.98[c]
Soaking			
Giza - 15	30.08± 3.35[b]	1.85± 0.112[c]	69.38± 1.08[b]
Ajakss	30.5± 2.96[b]	1.84± 0.135[c]	69.28 ±1.44[b]
Giza - 114	30.3±2.16[b]	1.78± 0.131[d]	68.64 ±1.36[c]
Germination			
Giza-15	31.5±3.42[a]	2.03± 0.34[a]	71.28 ±2.05[a]
Ajakss	31.2 ±4.16[a]	1.92± 0.25[b]	70.12± 1.97[a]
Giza - 114	31.0 ±4.32[a]	1.90 ±0.172[b]	69.91±1.35 [b]
L S D at 5%	3.572	0.0615	3.571

*PEV. Protein efficiency ratio **B.V. Biological value

Corresponding author
Maha A. Hejazi
Faculty of Home Economics - King Abd El-Aziz Univ., Saudi Arabia
baby1_248088@yahoo.com

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