ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

PRODUCTION OF SOY-FORTIFIDE WEANING FOOD

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Manuscript Info

Manuscript History:

Received: 12 April 2014
Final Accepted: 25 May 2014
Published Online: June 2014

Key words:
Change in nutritive value, Germination, Standardization of weaning food.

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Abstract

The germination of grain increases the moisture content, total sugar, reducing sugar, non-reducing sugar, protein, starch (amylose) content, water absorption index, particle size and water solubility index. Descriptive sensory analysis carried out by using the descriptive sensory analysis method of developed five-point measurement scale. The instrumental analysis for viscosity, flow behavior index and consistency of all samples carried out and these sensory and instrumental outputs feed to response surface methodology as responses for getting best composition by optimization. It is concluded that germination improve the nutritional and sensory properties of the weaning food due to changes in chemical composition and physicochemical characteristics of grains and also useful in health point of view since there is decrease in anti-nutritional factor as well as calorific value and increase in digestibility and nutrient availability.

INTRODUCTION

Germination of seeds is one of the best methods to be utilized the improvement of nutritional profile of the seed grains and which will be used for the development of various food products, and as in the present scenario people are more health conscious so the germination of cereals is of great importance both from nutritional as well as health benefits point of view. It not only improves the nutritional profile of the seed grains but also reduces some anti-nutritional factors which reflect the beauty of this method. It also improves the bioavailability of the various minerals, vitamins and dietary fibers, which are of immense significance from both health as well as nutritional point of view.Sorghum, Barley and soybean are cheaply and easily available in market and as we know these cereals and legumes when mixed together, it will fulfill the all-nutritional requirement. So we are trying to blend all these three beans out of which soybean is rich in protein and barley and sorghum has lot of nutritional and medicinal values since they contain large number of micronutrients. Weaning food prepared developed by using this blend is of low cost and highly nutritious with very good taste.

SORGHUM

Sorghum is a grain rich in starch (≥70% with approximately 75:25 amylopectin/amylose ratios) and it is primarily used in diets as an energy source **(Ezeoguet al., 2004)**. Sorghum kernels are generally spherical and have 1,000-kernel weight ranging from 20 to 30g, and may be red, white, yellow or brown **(Hoseneyet al., 1981)**. Proximate grain composition is 7.9% pericarp, 9.8% germ, and 82.3% endosperm, and unlike other cereals, many sorghum varieties contain starch granules in the pericarp **(Hoseney, 1994)**.

SOYABEAN

Botanically, soybean belongs to the order Rosaceae, family Fabaceae, subfamily Papilionoidae, the genus Glycine and the botanical name Glycine max. Soy beans contain large amounts of the Isoflavonesdiadzein, genistein a glycitein (1-3 mg/g) and their acetyl and malonyl conjugates **(Song et al., 1998)**. Soybean seed protein and oil are nutritionally and economically the most important. Starch content of mature soybeans is very low (0.19–0.91%) **(Wilson et al. 1978)**, which is similar to the high-oil containing peanut **(Isleibet al., 2004).** Starch of low-linolenic acid soybean variety was found to have significantly higher apparent amylose with protein source, processing treatment, and interaction with other components of the diet. Proteins that are deficient in one or more amino acids are of poor quality. For example, tryptophan and lysine are nutritionally limiting in corn, lysine in wheat and other cereals, and methionine in soybeans and other legumes. Germination enhances the nutritional quality of soybean seeds, presumably due to increased protein content and decreased content of non-digestible oligosaccharides **(Trugoet al., 2000)**.

Table 1: Amino Acid Composition of Soy Meal from a Standard Variety (Williams 82) and from a Strain Lacking KTI (L81-4590).

Amino Acids	Williams		82 KTI-free		FAO
	g/100g	g/16gof N	g/100 g	g/16 g of N	g/16 g of N
Aspartic acid	5.19	11.16	5.67	11.42	-
Serine	2.45	5.28	2.70	5.45	-
Glutamine	8.77	18.87	9.72	19.58	-
Proline	2.61	5.61	2.80	5.64	-
Lysine	2.88	6.20	3.15	6.35	5.5
Arginine	3.33	7.16	3.72	7.49	-

BENEFICIAL EFFECTS OF SOY-CONTAINING DIETS

Cholesterol-Lowering Effects of Soy Diets

Elevated plasma levels of low-density lipoproteins (LDL) and triglycerides present a risk for cardiovascular disease. By contrast, high-density lipoproteins (HDL) are beneficial. A low ratio of LDL to HDL and low plasma triglyceride levels decrease the risk of cardiovascular disease. The extent of LDL cholesterol-lowering by soy-based diets was dependent on the concentrations of naturally occurring estrogenic isoflavones **(Crouse et al., 1999)**. **Potter et al., (1998)** and **Washburn et al., (1999)** investigated the role of soy isoflavones on the risk of cardiovascular disease and menopausal symptoms in women consuming soy-based diets.

Soy protein may be useful in energy-restricted diets for the treatment of obesity **(Aoyama et al., 2000).**A soy-based diet slowed the progression of chronic renal failure in humans **(Soroka et al., 1998)**.Soybean, but not casein, diets protected rats against gastrointestinal mucosal injury caused by the widely used drug methotrexate **(Funk and Baker, 1991; McWilliams et al., 2000).** Soy isoflavones attenuated bone loss from the spine of premenopausal women **(Alekel et al., 2000; Somekawa et al.,2001).** Increases in Crude Protein Cont

Other Beneficial Effects

Soy protein may be useful in energy-restricted diets for the treatment of obesity **(Aoyama et al., 2000).**A soy-based diet slowed the progression of chronic renal failure in humans **(Soroka et al., 1998)**.Soybean, but not casein, diets protected rats against gastrointestinal mucosal injury caused by the widely used drug methotrexate **(Funk and Baker, 1991; McWilliams et al., 2000).** Soy isoflavones attenuated bone loss from the spine of premenopausal women **(Alekel et al., 2000; Somekawa et al., 2001).** Increases in Crude Protein Content **Morgan et al., (1992)** found that, “The protein content of sprouts increased from the time of germination, the absorption of nitrates facilitates the metabolism of nitrogenous compounds from carbohydrate reserves, thus increasing crude protein levels.

- **Increases in Protein Quality**
- **Increases in Crude Fibre Content**
- **Increases in Vitamin Content**
- **Reduction of Anti-nutritional Factors**

BARLEY

Barley is the fourth largest cereal grain crop produced worldwide, (after wheat, rice, and corn). **)**. As much as 90% of the barley grown is used in alcoholic beverage production and as livestock feed. Barley is an excellent source of complex carbohydrates, which constitute ≈80% of barley grain weight **(Czuchajowska et al., 1992, Szczodrak et al., 1992)**. Also, barley contains high levels of β-glucans, which are important contributors to dietary fiber, a crucial component of the human diet **(Newman and Newman, 1991; Granfeldt et al., 1994)**.

Composition of Whole Barley

Composition of three barley types is summarized in Table 2.5. Protein content ranged from 12.5% in high-amylose barley to 15.5% in waxy barley. Protein content varied in barley based on growing conditions, with an average value of 3%). β- Glucan content was highest in waxy barley (6.6%) and lowest in high-amylose barley (5.6%).

NUTRITIONAL BENEFITS OF BARLEY

Reducing Risk of Coronary heart disease and elevated blood cholesterol level. FDA Approved CHD Risk Reduction Health Claim for Beta-Glucan Soluble Fiber from Barley.

- Reducing Blood Glucose with Barley.
- Increasing Satiety with Barley

Biochemistry of germination of barley

Starch – source of carbohydrate for brewing. Gelatinization occurs at 52.9^{0}C Germination – occurs at 15^{0}C. Amylases have to act on non-gelatinized starch this is clearly not efficient. Two forms of starch in the grain – amylose and amylopectin. Amylose is 1000-4000 glucose units, straight chain α-1,4 linkages. Amylopectin is a larger molecule, in excess of 2000 glucose units with branched α-1,4 and α-1,6 linkages. Starch is degraded to smaller polysaccharides using the following enzymes α-amylase, β-amylase, α-glucosidase, phosphorylase and other debranching enzymes.β-amylase is present in the barley in an inactive form which is subsequently activated. Among the amylolytic enzymes, α-amylase (1,4-α-D-glucanohydrolase) is thought to be the only enzyme which can initiate the cleavage of native starch granules by hydrolyzing α-1,4-linked glucose polymers

Enzyme Development in Whole Germinating Barley

Carboxypeptidase and β-glucanase activities were split 3:2 between the proximal end and distal ends. Arabinofuranosidase activity was in a ratio of 2:1, and α-amylase was between 3 and 4:1. Xylanase activity showed a 1:1 ratio of activity between the proximal and distal ends. late development of arabinofuranosidase would suggest that the removal of arabinose from the xylan backbone is not an a priori requirement for the hydrolysis of arabinoxylan. The α-amylase, β-glucanase and arabinofuranosidase activities had two plateaus each. Xylanase and carboxypeptidase had three plateaus. Total activity did not constantly increase for each enzyme during the entire 144 h. Total α-amylase activity increased until maximum activity at 120 h, after which total activity dropped. The β-glucanase and carboxypeptidase total activities increased until 132 h, at which point they dropped as well

Table 2: Composition (%) of Whole Barley Kernels

Barley	Protein	Ash	Free Lipids	Starch	Total β-Glucans
Non-waxy	13.6ba	2.11c	2.60	67.6a	6.21ab
High-amylose	12.5c	3.01a	2.16b	65.2b	5.56c
Waxy	15.5a	2.61b	2.65a	65.6b	6.60a

Table 3: Macronutrient Content of Barley Grains.

Nutrient	Barley (per 100g)
Calories (Kcal)	354
Protein (g)	12.48
Fat (g)	2.30
Total Carbohydrate (g)	73.48
Total Dietary Fiber (g)	17.3

MATERIALS AND METHOD

Germination of grains

Barley

Barley grains were cleaned and soaked separately in water (seed to water ratio of 1:5 w/v was maintained) for 12h at room temperature (30°C). The soaked grains were germinated in clean plates lined with wet filter paper for 24-96h at 37°C with frequent spraying of water, the sprouts were rinsed in water , dried at 55-60°C and pulverized to fine powder (sieved through 60 mesh sieve).

Soyabean

Soyabean grains were cleaned and soaked in potable tap water for 12 h at room temperature and grain to water ratio was 1:3 (1 part grain and 3 parts water). The soaked samples were incubated for 96h in an incubator at 27°C after placing in sheets with frequent spraying of water the sprouts were rinsed in water, dried initially at 80°C for 15 min and then dried in tray drier at 55-60°C till constant weight.

Sorghum

Sorghum grains were cleaned and soaked in potable tap water for 12 h at room temperature and grain to water ratio was 1:3 (1 part grain and 3 parts water). The soaked samples were incubated for 72h in an incubator at 25°C after placing in sheets with frequent spraying of water the sprouts were rinsed in water, dried at 20°C for 48 hours or dried in tray drier at 55-60°C till constant weight

Grains of barley, soya bean and sorghum were obtained as and these grains of barley, soya bean and sorghum were germinated as per methods described after germination these grains were grounded coarsely and passed through the sieve of size 25µ.

Formulation of weaning food

Blended weaning food should be in granular form and should be manufactured using germinated sorghum flour, soybean flour, barley, ghee, sugar as following composition-

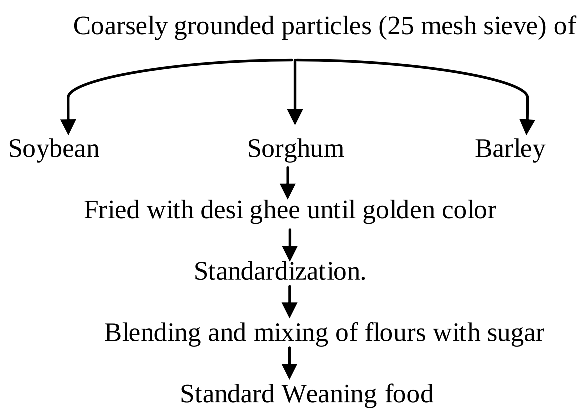

Table 4: Micronutrients

Sr. No	Parameters	Proportion
1	Protein	12-15g
2	Calories	500cal
3	Iron	6mg
4	Vitamin A	200mcg
5	Calcium	200mg
8	Niacin	4mg
9	Vitamin C	15 mg
10	Free folic acid	15mcg

Table 5: Chemical Analysis –

Sr. No	Parameters	Specification
1	Moisture	4.0%max
2	Total Ash	5.0% max
3	A.I Ash	0.15% max
4	Crude fiber	1.0% max

Rheological Properties of weaning food

Viscosity

The flow-behaviour index (η) was calculated as a slope of the curve plotted between log of dial readings and log of rpm. The shear rate at different revolutions per seconds was then obtained using the following equation

(Borras, 1965): $\gamma = 4\pi N/\eta$

Where; γ = Shear rate (1/sec), N=revolutions per seconds, η= Flow behaviour index.

The shear stress was calculated using Newtonian law :

$$\tau = \mu_a \times \gamma$$

Where; γ = Shear rate (1/sec), τ = shear stress (m Pa), μ_a = apparent viscosity (mPa·s)

The consistency coefficient (k) (mPa·s^n) calculated according to Ostwald de Waele power-law model **(Toledo, 2000)**:

$$\tau = k \times \gamma$$

Phytic acid content of weaning food

Find out the fig iron present in the test from the standard curve, and calculate the phytate P as per the equation:

$$\text{Phytate P (mg)} = \frac{\text{mg Fe x 15}}{\text{weight of sample (g)}}$$

RESULTS AND DISCUSSION

OPTIMIZATION OF GERMINATION PROCESS

1. **Soaking**

In 12 hrs. of soaking of grains, out of 15 grains of soybean taken, 14 grains got germinated, that of barley 14 grains and in sorghum 15 grains were germinated. After 8hrs.Soaking out of 15 grains of soybean 11 grains were germinated, in case of barley 10 grains and that of sorghum 12 grains got germinated. Similarly for 4hrs. Soaking out of 15 grains of soybean9 grains got germinated, that of barley 7 grains and in sorghum 6 grains were germinated. Samples in duplicate taken and average values reported**.** These results were similar to the results obtained by **Dogra et al., (2001).**

Table 6: Effect of soaking time on germination capacity of soybean, sorghum and barley grains.

No. of grains Germinated after → / No. of grains taken ↓	4hrs soaking	8hrs soaking	12hrs soaking
Soybean (15)	9	11	14
Sorghum (15)	6	12	15
Barley (15)	7	10	14

2. **Germination**

The 12 hrs soaked grains of soyabean, sorghum and barley when kept for germination in humidity chamber at temperature of 25 ± 2^0C for 24hrs, 48hrs, 72hrs and 96hrs. The results obtained are shown in Table (7).

Table 7: Chemical Changes during the Germination

	Germination Time → / Constituents (%) ↓	0 hrs	24 hrs	48 hrs	72 hrs	96 hrs
Soyabean	**Carbohydrate**	22.1^e ±0.25	21.0^d ±0.27	19.54^c±0.31	18.67^b ±0.25	17.9^a ±0.41
	Protein	29.09^a±0.05	30.94^b±0.09	32.12^c±0.15	33.19^d ±0.25	34.99^e ±0.25
	Fat	24^e ±0.40	21^d ±0.45	19^c ±0.45	16^b ±0.50	10^a ±0.45
Sorghum	**Carbohydrate**	70.02^e±0.25	67.04^d±0.25	65.02^c±0.26	63.01^b ±0.25	60.04^a ±0.27
	Protein	7.25^a ±0.27	7.99^b ±0.28	8.24^c ±0.25	9.02^d ±0.25	9.85^e ±0.26
	Fat	6^e ±0.40	5.6^d ±0.35	5.18^c ±0.25	4.9^d ±0.32	4.0^e ±0.29
Barley	**Carbohydrate**	72.02^e±0.25	67.87^d±0.26	65.01^c±0.25	63.12^b ±0.26	61.06^a ±0.25
	Protein	11.25^a±0.25	11.98^b±0.24	12.23^c±0.26	12.96^d ±0.26	13.85^e ±0.27
	Fat	7^e ±0.35	6.2^d ±0.27	5.34^c ±0.26	5^d ±0.28	4^a ±0.40

Values are mean of 3 determination ± S.D. a to e character show significant difference in each row ($P \leq 0.05$)

ssCHANGES IN CHEMICAL COMPOSITION OF GRAINS UPON GERMINATION

Germination is induced by rehydration of the seed, which increases both respiration and metabolic activity thus allowing the mobilization of primary and secondary metabolites **(Limami et al., 2002).**

SOYABEAN

The moisture content of un-germinated and germinated flour samples of soyabean varied between 10% to 11% (wb). The soaking, germination and heating treatments given to soyabean grains significantly decreased the total carbohydrate contents from 22.1% to 17.9%.This was because of active respiration process during soaking and germination. The germination of soyabean had significantly increasing effect on protein content, which increases from 29.09 % to 34.99 %. Crude fibre increased significantly in germinated soyabean grains initially from 14.4 % to 18.6 % **(Table 8).**

Table 8: Chemical composition of un-germinated and germinated flours of soyabean.

Samples → / Constituents (%) ↓	Un-germinated Soybean Flour	Germinated Soybean Flour
Moisture	10^{a} ±0.30	11^{b} ±0.26
Crude fiber	14.4^{a} ±0.26	18.6^{b} ±0.27
Carbohydrate	22.1^{b} ±0.26	17.9^{a} ±0.25
Starch	12.23^{b} ±0.24	10.21^{a} ±0.26
Protein	29.09^{a} ±0.27	34.99^{b} ±0.22
Fat	24^{b} ±0.26	10^{a} ±0.28

Values are mean of 3 determination ± S.D. a to e character show significant difference in each row (P≤ 0.05)

SORGHUM

There was decrease in the total carbohydrate contents of sorghum grain from 70.2 % to 60.4 %. This was because of active respiration process during soaking and germination. On the other hand, soaking, germination and heating increased the reducing sugar content from 2.81% to 3.82%, non-reducing sugar content from 6.11% to 8.16 % and total sugars content from 8.92% to 11.98%. The germination of sorghum had an increasing effect on protein content 7.25 % to 9.85 %. **Tatsadjieu et al., (2004)** and **Khader, (1983)** reported that there is increase in protein content during prolonged germination of sorghum. The fat content in present study decreased from 6 % to 4 % after soaking, germination (96hrs) and heating (55-60^{0}C) and this is due to increased activity of lipase enzyme. The starch content of sorghum decreased from 65.2 % to 58.1% during soaking, germination (96hrs) and heating. The increased α-amylase and β-amylase activities correspond with the decrease in the starch content, increase in amylose content from 11.5% to 15.8% and decrease in amylopectin from 53.7 % to 42.3 % in germinated soyabean flour and these results are in agreement with those of **Sharma et al. (2007)** and **Palmer (1989).**

Table 9: Chemical composition of un-germinated and germinated flours of sorghum

Samples → / Constituents (%) ↓	Un-germinated Sorghum Flour	Germinated Sorghum Flour
Moisture	9.9^{b}±0.27	10.2^{a}±0.28
Crude fiber	3.59^{b} ±0.24	6.51^{a} ±0.20
Carbohydrate	70.02^{b} ±0.25	60.04^{a} ±0.28
Reducing sugar	2.81^{a} ±0.24	3.82^{b} ±0.22
Starch	65.2^{b} ±0.23	58.1^{a} ±0.26
Protein	7.25^{a} ±0.27	9.85^{b} ±0.28
Fat	6^{b} ±0.27	4^{a} ±0.24

Values are mean of 3 determination ± S.D. a to e character show significant difference in each row (P≤ 0.05)

BARLEY

The moisture content of un-germinated and germinated flour samples of barley varied between 9.6 % to 11.2% (wb). The soaking, germination and heating treatments given to barley grains decreased the total carbohydrate contents from 72.02 % to 61.06 % in germinated flour of barley. Total sugars from 9.03 % to 12.98 % due to activities of α-amylase and

β-amylase enzymes which increase with soaking and subsequent germination. The germination of barley had an increasing effect on protein content from 11.25% to 13.85 %. Increase in amylose content from 16.08% to 18.02% and decrease in amylopectin from 43.48 % to 38.30 % in germinated barley flour.

Table 10: Chemical composition of un-germinated and germinated flours of barley

Samples → / Constituents (%) ↓	Un-germinated Barley Flour	Germinated Barley Flour
Moisture	9.6^{a} ±0.27	11.2^{b} ±0.27
Carbohydrate	72.02^{b} ±0.28	61.06^{a} ±0.29
Total sugar	9.03^{a} ±0.24	12.98^{b} ±0.26
Reducing sugar	2.82^{a} ±0.18	4.73^{b} ±0.19
Amylose	16.08^{a} ±0.20	18.02^{b} ±0.29
Amylopectin	43.48^{b} ±0.28	38.30^{a} ±0.22
Protein	11.25^{a} ±0.24	13.85^{b} ±0.20

Values are mean of 3 determination ± S.D. a to e character show significant difference in each row (P≤ 0.05)

CHANGES IN NUTRITIONAL COMPOSITION OF WEANING FOOD

The phytic acid present in dry composition of ungerminated weaning food was reduced from 8.7 (mg/g) to 2.3 (mg/g) in germinated one so there is significant decrease in antinutritional factor after soaking (12hrs), germination (96 hrs) and heating (55-60^{0}C) of grains, and this decrease in antinutritional factor is due to metabolic activities including increased enzymatic activity. The calorific value of dry composition of un-germinated porridge with all dry ingredients get reduced from 439.35 (Kcal/130g) to 295.48 (Kcal/130g) in germinated one so there is significant decrease in calorific value after soaking (12hrs), germination (96 hrs) and heating (55-60^{0}C) of grains.

Table11: Nutritional status of germinated and un-germinated weaning food compositions

Porridge (Optimized sample)	Un-germinated	Germinated
Phytic acid (mg/g)	8.7^{b} ± 0.152	2.3^{a} ± 0.152
Total calorific value (kcal/130 gm)	439.35^{b} ± 0.402	295.48^{a} ± 0.352

Values are mean of 3 determination ± S.D. ato e character show significant difference in each row (P≤ 0.05)

SUMMARY AND CONCLUSION

The germination of barley, sorghum and soybean was carried out under the controlled conditions of soaking, germination and heating. To get best results nutritional point of view and to get all the grains germinate at their optimum capacity we have carried out heat and trial method for all the grains at different soaking and germination time. In the chemical composition of all three grains of barley sorghum and soyabean there is decrease in ash content, carbohydrate, fat, starch, amylopectin and falling number and increase in moisture, total sugar, reducing sugar, non-reducing sugar, amylose content and protein content; this is due to metabolic activity including respiration, enzymatic activity, etc. Conclusively the germination of grains increases nutritional value by reducing the anti-nutritional factors, total calorific value and desirable degradation and synthesis of nutrients due metabolic activities including respiration, enzymatic activity and synthesis of new molecules and degradation of macromolecules.

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