J Food Sci Technol (May 2014) 51(5):915–921
DOI 10.1007/s13197-011-0576-9

ORIGINAL ARTICLE

Effect of sprouting of soybean on the chemical composition and quality of soymilk and tofu

D. Agrahar Murugkar

Revised: 20 September 2011 / Accepted: 17 October 2011 / Published online: 3 November 2011

Abstract The effect of sprouting of soybean and preparing soymilk and tofu on the yield, nutritional quality, anti-nutritional profile, colour attributes, organoleptic quality and texture profile (tofu) of four commonly used varieties of India were studied to assess the feasibility of using sprouting as a non-chemical, non-thermal tool to improve quality of soy products. Soymilk was prepared from sprouted and unsprouted seeds with process parameters of 121 °C for 25 min. Coagulation of soymilk was done with 3% $CaSO_4$ at 80 °C. Products from sprouted varieties showed an increase in protein (fb) of 7% in milk and 13% in tofu across varieties; a reduction in fat (fb) of 24% in milk and 12% in tofu; in trypsin inhibitor (db) of 73% in milk and 81% in tofu; in phytic acid (db) of 59% in milk and 56% in tofu across varieties. Tofu from sprouted seeds had higher protein and whiteness index but tofu strength was around 43% lesser than its unsprouted counterpart. Taste acceptability showed an increase of 10% and 6.3%; flavour of 23.2% and 11.6% and overall acceptability of 9.9% and 4.4% in milk and in tofu respectively from sprouted varieties. The improvements in composition and quality parameters was seen in all the varieties tested showing that sprouting could be beneficial for product development across varieties. The time and temperature used for production of soymilk was conventional (121 °C for 25 min). Evaluation of time and/temperature reductions could be tried out to reduce the heat requirement and intensity, which could result in better nutritional and functional quality products

D. A. Murugkar (✉)
Agro-Produce Processing Division,
Central Institute of Agricultural Engineering,
Bhopal, India 462 038
e-mail: dipikaagrahar@yahoo.com

Keywords Sprouting · Soymilk · Tofu · Nutrients · Trypsin inhibitor · Phytic acid · Texture · Organoleptic quality

Introduction

Sprouting of soy has been known to be beneficial for the reduction of anti-nutrients like trypsin inhibitor, phytic acid, flatulents etc. Soymilk prepared by traditional method presents some problems and many workers have tried to improve the quality by elimination of off flavour (Nelson et al. 1976; Matsuura et al. 1989); inhibiting the anti nutritional factors (Luttrell et al. 1981; Weingartner 1987); reducing the phytic acid content (Ologhobo and Fetuga 1984); improving soymilk yield (Lee and Karunanithy 1990) etc. All these efforts generally take care of one or two of the problems associated and use heat intensive methods for anti-nutrient reduction thereby reducing the overall nutritional quality of soymilk.

Tofu or soybean cheese is produced traditionally by curdling soymilk with either salt ($CaCl_2$ or $CaSO_4$) or an acid (glucuno-d-lactone) (Oboh 2006) to get a soy protein gel, which traps water, soy lipids and other constituents in the matrix forming curds. The curds are then pressed into solids (Cai et al. 1997; Cai and Chang 1998). The quality of the beans, the amount of stirring, the coagulants, and the pressing of the curd can have a high impact on the quality of the final product (Wang and Chang 1995).

It is known that during sprouting, a sequence of metabolic changes are triggered, improving the nutritional quality of sprouted legumes and decreasing the anti-nutritional factors such as trypsin inhibitor and phytic acid (Agrahar Murugkar and Jha 2009). Thus the sprouting of soybean would facilitate development of products like soymilk and tofu (coagulated and compressed product of soymilk), which are normally, prepared using heat moisture treatment causing denaturation of protein. Therefore the present study was taken up to investigate the effect of sprouting of soybean seed and preparing soymilk and tofu on the yield, nutritional quality, anti-nutritional profile, colour attributes, organoleptic quality and texture profile (tofu) of four commonly used varieties of India.

Materials and methods

Sprouting of soybean Soybean varieties 'DSb-1', 'JS335', 'MAUS47' and 'MAUS71' grown in different regions of India were selected as material for analyzing effect of sprouting on yield and quality of soymilk and tofu. The soybean varieties 'DSb 1', 'JS9305', 'MAUS 47' and 'MAUS 71' were procured from University of Agricultural Sciences Dharwad, Karnataka; National Research Centre on Soybean, Indore, Madhya Pradesh and the last two varieties from Marathwada Agricultural University, Parbhani, Maharashtra respectively to represent the major soybean growing states of India. Varietal differences have been reported in literature and it would be interesting to observe these differences in our study. These cultivars were harvested in November 2009 and stored at 20 °C for further studies. Soybean seeds were cleaned thoroughly and made free from dust, dirt, stubbles and foreign matter. Damaged seeds with cracked hull etc. were discarded and the seeds were surface sterilized with 0.1% (*w*/*v*) potassium permanganate solution for 5 min. They were then rinsed with distilled water to remove any traces of potassium permanganate. Seeds were soaked in distilled water for 4 h at room temperature (RT). Then, the excess water was drained, sample further rinsed with distilled water, seeds placed in a single layer on filter paper in sterile petridishes and placed in the Seed Germinator (Indosaw India) at the 25 °C, 90% RH for 72 h. as per the method of Agrahar Murugkar and Jha (2009).

Soymilk preparation Soymilk from the four varieties both sprouted and unsprouted was prepared using the Soycow model SC 100 (Gupta and Gupta 1990) method shown in Fig. 1. For the preparation of milk from sprouted seeds, the seeds and cotyledons were utilized and the hulls discarded. Around 1 kg of soybean per batch was taken both for control and treatment which is the minimum amount required for the Soy Cow model. In unsprouted seeds dehulled soy splits were used as the start material, which was soaked for 4 h in water at RT and then fed into the unit. The sprouted seeds which had around 60% moisture were dehulled manually and then fed into the grinding cum blanching unit with 5 times the volume of water to a pressure of 1 kg/cm^2 (15 psi) by infusing culinary steam at

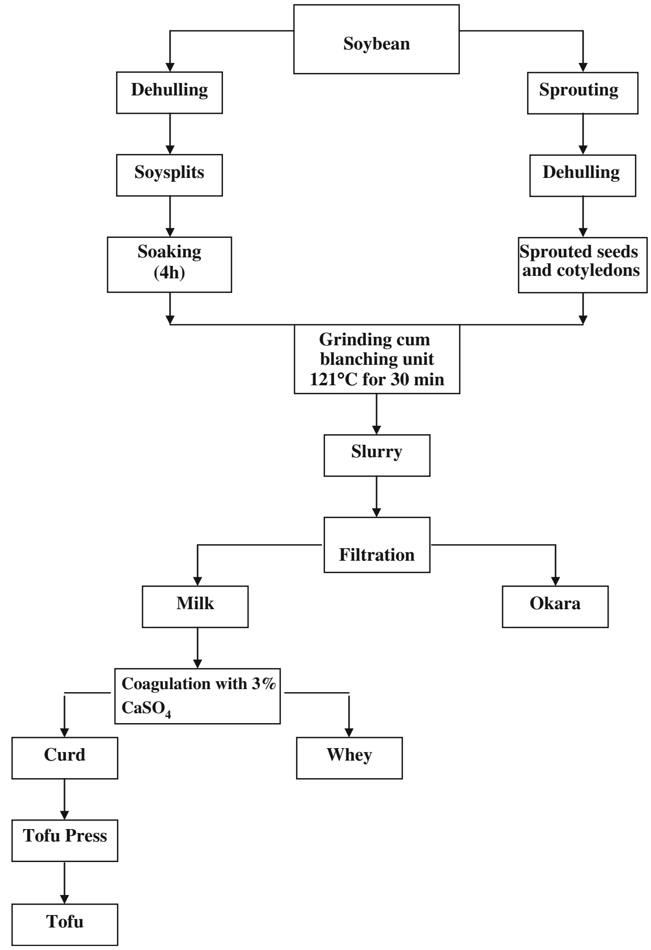

Fig. 1 Process chart of preparation of soymilk, tofu and okara from sprouted and unsprouted seeds

a pressure of 1–3 kg/cm^2 (15 to 54 psi). The temperature of the slurry in the unit was allowed to reach 121 °C from RT, which took about 30 min (including grinding). The whole process was carried out in vacuum. After the pressure from unit was released, filtering and mechanically pressing of the okara extracted the soymilk.

Tofu preparation Milk obtained from the above process was cooled to around 80 °C subsequently 3% calcium sulphate was added (of the total milk obtained). The mixture coagulated and the tofu was separated from the whey using a muslin cloth after which it was pressed in a tofu press.

Analyses The moisture content and dry matter content of soymilk and tofu was determined by the method given by AOAC (1984). The relative viscosity of soymilk was determined by the method given by Ranganna (1977). Soymilk yield was determined by the method of Gesinde et al. (2008). Soymilk index is the summation of Soymilk yield (ml g^{-1} of seed), Total solids (g kg^{-1}), Soymilk protein (g kg^{-1}) and Whiteness index (Wi) (Bharadwaj et al. 1999). The yield of tofu was calculated as the percentage of weight (g) of fresh tofu obtained from a specified amount of the soymilk used for its preparation (Prabhakaran et al. 2006). Tofu index is the summation of Tofu yield (g mL^{-1}), Tofu strength (N), Tofu protein (g kg^{-1}) and Whiteness index (Wi) (Bharadwaj et al. 1999). Percent protein extractability was calculated as the protein percentage, which was extracted from soybean seeds into soymilk (Bharadwaj et al. 1999). The solid content and crude protein and fat contents of the soymilk and tofu were estimated by the standard methods (AOAC 1995). Trypsin inhibitor (TI) activity was determined by standard procedure of Kakade et al. (1974) as modified by Hammerstrand et al. (1981). The phytate content of tofu was assayed using Latta and Eskin (1980).

Determination of colour For Colour the samples were taken for the measurement of colour using lab scan XE spectrocolorimeter (model no LX16244, Hunter Associate Laboratory Virginia, USA) in terms of CIE 'L' (lightness) 'a' (redness and greenness) and 'b' (yellowness and blueness) following the method of Chantrapornchai et al. (1998). ΔE (colour difference) values were calculated using the following formula: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$, where ΔL, Δa and Δb are the differences in the specified tristimulus coordinate between the sprouted and unsprouted soymilk and tofu with commercial soymilk and tofu used as control (ΔE-1) and also sprouted soymilk and tofu with unsprouted soymilk and tofu as control (ΔE-2).

Texture analysis of tofu The texture profile of tofu was determined using the Texture Analyzer (TA-XT2i) of Stable Microsystem equipped with a 5 kg load cell. The analyser is linked to a computer that recorded data via a software program Texture Expert (Texture Technologies Corp., New York, USA). Samples of length, width and height of 25.4 mm were cut from the central portion of tofu cake with a stainless steel cutter. A Flat plate probe of 75 mm diameter was used. The pre, test and post-test speed was 1 mm/min. Each sample was compressed twice to 50% of its height with trigger force of 0.05 N and 5 s time gap between the two compressions. Data was acquired at 200 points per second. Force versus displacement was recorded. Hardness, Cohesiveness, Springiness and Chewiness of tofu were determined using the method described by Kotwaliwale et al. (2007).

Sensory evaluation of tofu Sensory evaluation was done on freshly made soymilk and tofu. Ten semi-trained panelists evaluated the sensory attribute of fresh tofu. Panelists were familiar with product sensory evaluation, most having participated in previous related projects. Milk was served in glasses and tofu was cut into cubic samples and placed of plastic plate with a random number (Cai and Chang 1998). The attributes evaluated were colour, flavour, mouth feel and overall acceptability. For each sample, panelists scored their liking of theses characteristics using the nine point Hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely).

The experiment was conducted in triplicate and the data was then statistically analysed using statistical packages of SYSSTAT 7.0 for Windows

Results and discussion

Effect of germination on the protein, fat, TI and phytic composition (Table 1)

A significant ($P<0.5$) increase in crude protein and a significant ($P<0.5$) reduction in fat, TI and phytic acid was seen in milk and tofu made from sprouted soybean vis a vis the unsprouted varieties. Products from sprouted varieties showed an increase in protein (fresh basis) of 7% in milk and 13% in tofu across varieties (percentage increase in content (ie protein) of sprouted product over content in unsprouted product). Similarly a reduction in fat (fresh basis) of 24% in milk and 12% in tofu; in trypsin inhibitor (mg/g dry basis) of 73% in milk and 81% in tofu; in phytic acid (mg/100 g dry basis) of 59% in milk and 56% in tofu across varieties. Apart from a significant reduction in TI and phytic acid between sprouted and unsprouted varieties there was a significant difference within varieties as well. These observations could be explained considering the fact that during sprouting, there is a breakdown of reserve protein to give NH_3, which accumulates, in the form of amide such as glutamic acid and aspartic acid (Hsu et al. 1980) while depletion of the fat stored is due to the catabolic activities of the seeds during sprouting Mostafa et al. (1987) which agrees with our results. Fat content value in soymilk prepared be raw seeds were similar a reported by Achouri et al. (2008). Sprouting can degrade both Kunitz soybean trypsin inhibitor and the major Bowman-Birk soybean trypsin inhibitor (Collins and Sand 1976) due to the proteolytic activity of enzymes, which are activated during sprouting (Chauhan and Chauhan 2007). Sprouting reduced the phytic acid content which is confirmed by other investigators due to the possibility of increased phytase activity by 3 to 5-fold in some cereal grains and legume seeds (Egli et al. 2002; Dave et al. 2008).

Table 1 Chemical composition of soymilk and tofu from raw and sprouted soybean varieties

Variety	Dry matter%	Protein g% fb[a]	Fat g%fb[a]	TI mg/g db[a,b]	Phytic acid mg% db[a,b]
Milk					
JS335 R	7.7±0.1	3.9±0.4	2.0±0.14	9.1±0.07	110.1±2.3
JS335 G	8.1±0.01	4.1±0.13	1.5±0.23	1.9±0.19	66.0±1.20
DSb1 R	8.4±0.92	3.8±0.12	2.4±0.56	5.7±0.04	93.2±1.03
DSb1G	8.8±0.43	4.0±0.13	1.9±0.41	1.6±0.07	55.0±0.26
MAUS47 R	6.9±0.91	3.7±1.80	2.5±0.33	13.5±0.33	236.3±10.3
MAUS47G	7.5±0.01	3.9±1.85	1.5±0.24	4.5±0.33	80.0±10.3
MAUS71R	8.7±0.10	3.4±1.09	1.9±0.23	13.9±0.19	260.3±2.5
MAUS71G	9.1±0.96	3.9±1.24	1.8±0.37	3.2±0.07	82.4±12.9
Tofu					
JS335 R	24.9±0.04	12.1±0.66	6.1±0.23	7.1±0.03	110.0±2.37
JS335 G	26.8±1.3	15.5±0.22	5.4±0.15	1.05±0.02	93.5±1.03
DSb1 R	24.8±1.0	15.3±0.23	6.1±0.61	6.8±0.06	95.5±1.13
DSb1G	26.2±1.5	16.5±0.58	4.9±0.11	1.33±0.02	55.5±0.26
MAUS47 R	31.1±0.39	11.8±0.13	5.2±0.41	5.99±0.03	236.4±10.29
MAUS47G	32.0±0.8	13.9±0.01	5.0±0.31	1.45±0.04	80.0±1.29
MAUS71R	25.4±0.55	15.7±0.01	6.9±0.26	7.01±0.02	266.0±2.57
MAUS71G	25.5±0.31	16.2±0.28	5.8±0.22	1.24±0.03	81.8±1.26

R raw, *G* sprouted

[a]Significant between raw and sprouted soybean $P<0.5$

[b]Significant between varieties $P<0.5$

Sprouting as explained above brings down the fat, TI and phytic acid content in the seed itself (Agrahar Murugkar and Jha 2009) and therefore on further processing in milk and tofu the levels are further significantly reduced.

Effect of sprouting on yield characteristics of milk and tofu (including texture of tofu) (Table 2)

Viscosities of the soymilk samples from different varieties were significantly different ($P<0.5$) in sprouted samples. Viscosity ranged from 2.7 (DSb1-sprouted) to 3.2 (JS335 Ranchi raw). The results are similar to earlier studies (Achouri et al. 2008) and the decrease could be due to increased solubility of proteins, decrease in fat content on sprouting (Agrahar Murugkar and Jha 2009).

The Soymilk yield (ml g-l) ranged from 6.2 (MAUS47 raw) to 6.6 (MAUS47 sprouted), which are close to the yields found by Achouri et al. (2008). Though not significantly different, the yields of soymilk from sprouted samples were higher than milk from raw samples by about 3%.

The soymilk index was obtained by summing yield, total solids, protein content and whiteness index of soymilk (Bharadwaj et al. 1999). Soymilk index for milk made from unsprouted seeds varied from 933 in MAUS47 to 1,008 in DSb-1. For sprouted soymilk the index ranged from 954 in MAUS71 to 1,035 in DSb-1.There was increase in soymilk index of milk samples prepared from sprouted seeds as compared to those prepared by unsprouted seeds. These differences probably due to increase in protein during sprouting and high Wi value during sprouting.

Percent extractability is the protein percentage, which is extracted from soybean seeds into soymilk as given by Bharadwaj et al. (1999). Extractability (%) was highest in DSb1G (90.05) and lowest in JS335 G (84.31) for soymilk prepared from sprouted seeds. Extractability varied from 83.00 in MAUS 71 R to 89.63 in DSb1R for soymilk prepared from unsprouted seeds.

Yield of tofu (g/ml) was around 0.2 in both made from unsprouted and sprouted seeds across all varieties. This was despite the fact that the protein content in tofu from sprouted seed was higher by 12%. The similarity in yield may have been due to the similar corresponding decrease in fat in tofu from sprouted seeds. Tofu index is a summation of protein, tofu hardness and whiteness (Bharadwaj et al. 1999). Tofu from sprouted seeds had higher protein and whiteness index but tofu strength was around 43% lesser than its unsprouted counterpart. This resulted in the tofu index being 5% lesser in the unsprouted counterpart across varieties though the difference was not statistically significant. Suitability of tofu for preparing various culinary dishes is greatly influenced by its texture. Due to sprouting resulting in a decrease in fat content and increased solubility of proteins the hardness and chewiness of tofu was lower while cohesiveness and springiness was higher in tofu from sprouted seeds. Softer tofu is a preference for many culinary dishes and tofu from sprouted seeds would serve this purpose.

Table 2 Characteristics of soymilk and tofu from raw and sprouted soybean varieties

Variety	Soymilk				Tofu						
							Texture				
	Viscosity[a]	Yield (ml g-1)	SMI[a,b]	Extractibility (%)[b]	Yield (g ml-1)	Tofu index	Hardness[a]	Cohessiveness	Springiness	Chewiness[a]
JS335 R	3.2±0.23	6.6±0.37	955.3±8.51	86.8±2.71	0.2±0.03	565.8±10.23	11.5±2.76	0.38±0.051	0.51±0.192	2.4±1.12
JS335 G	2.9±0.21	6.8±0.29	966.6±10.12	86.3±1.90	0.2±0.03	536.8±9.65	5.7±1.22	0.43±0.051	0.60±0.031	1.5±0.44
DSb1 R	2.9±0.37	6.7±0.59	1008.2±6.34	89.6±2.33	0.2±0.02	594.4±7.66	11.8±1.56	0.37±0.024	0.59±0.034	1.3±0.33
DSb1G	2.7±0.20	6.6±0.19	1035.7±12.13	90.1±2.15	0.2±0.05	577.1±8.65	6.5±1.18	0.43±0.031	0.65±0.038	1.2±0.07
MAUS47R	3.1±0.24	6.2±1.08	933.5±9.54	86.3±1.93	0.2±0.06	615.5±9.56	11.4±1.47	0.37±0.071	0.45±0.203	2.5±0.30
MAUS47G	2.8±0.24	6.6±0.86	999.8±10.61	89.0±1.84	0.2±0.00	564.6±10.43	6.6±1.25	0.47±0.132	0.56±0.201	1.7±0.27
MAUS71R	2.9±0.40	6.6±1.01	948.1±11.30	84.0±2.51	0.2±0.01	598.7±11.02	11.4±1.36	0.30±0.553	0.48±0.293	1.5±0.33
MAUS71G	2.9±0.16	6.7±0.94	954.5±7.69	85.9±2.20	0.2±0.07	579.3±6.33	7.0±1.10	0.45±0.022	0.54±0.371	1.2±0.14

SMI soymilk index, *R* raw, *G* sprouted

[a] Significant between raw and sprouted soybean $P<0.5$

[b] Significant between varieties $P<0.5$

Effect of sprouting on colour of milk and tofu (Table 3)

In soymilk colour values of L, a, b were similar between sprouted and unsprouted varieties. The ΔE when soymilk from our experiments was compared to commercial soymilk it was observed that in unsprouted varieties ΔE-1 was lower (4.8) than that of germinated varieties (6.3). However in the case of tofu a significant ($P<0.5$) difference was seen between commercial tofu and tofu from unsprouted varieties (ΔE-1 6.3) whereas difference between commercial tofu and tofu from sprouted beans (ΔE-1 2.5) was significantly lower. No significant differences in ΔE values were observed when sprouted soymilk and tofu was compared to unsprouted soymilk and tofu. ΔE-2 was the highest in JS 335 (3.74) in milk and lowest (0.50) in MAUS 47 whereas in tofu the highest ΔE values were 8.98 in JS335 and lowest in DSb1 (2.80). This showed that the colour of sprouted soymilk and tofu closely resembled that of its unsprouted counterparts and would easily gain acceptance in populations who consumed these products.

Effect of sprouting on sensory characteristics (Table 4)

On a 9-point hedonic scale Significant ($P<0.5$) differences were observed in the taste, flavor and overall acceptability of milk and tofu from sprouted varieties. Taste acceptability showed an increase of 10% and 6.3%; flavour of 23.2% and 11.6% and overall acceptability of 9.9% and 4.4% in milk and in tofu respectively from sprouted varieties. Taste and flavour are two very important constituents to like or dislike a product. The presence of beany flavour and off smell of soy products is one of the biggest hindrances in its promotion as a healthy food. Sprouting is known to reduce undesirable flavors such as beany and grassy to a minimum and maximise total acceptability for the soymilk prepared from soybeans germinated for two days as well as in rotted nutty odor and taste (Kim et al. 1986) which is in line with our results. In other variables like texture of tofu a decrease in the hardness as seen in texture analysis did not seem to proportionally affect its sensory acceptability. In fact the marginal difference of 1.5% goes to show that some of the respondents preferred the softer tofu. Colour values in terms of sensory evaluation gave a similar response showing that the respondents found no difference in the colour of milk and tofu from sprouted or unsprouted varieties.

Conclusion

Sprouting of soybean not only increases protein content but also reduces fat, trypsin inhibitor and phytic acid whose

Table 3 Colour attributes of milk and tofu

Variety	L	a	b	Yi	Wi	ΔE1	ΔE2
Soymilk							
Commercial	84.5±3.22	−0.46±0.021	15.5±0.32	–	–	0	0
JS335 R	85.8±4.05	−0.79±0.031	12.1±0.0.21	22.5±0.33	7.3±0.98	4.5±0.23	0
JS335 G	82.6±1.33	−0.14±0.012	14.1±0.22	27.3±1.21	−10.4±0.36	6.7±0.58	3.7±0.32
DSb1 R	84.4±5.20	−0.06±0.012	11.4±0.12	22.2±1.03	7.6±1.20	4.0±0.44	0
DSb1G	83.2±2.62	0.04±0.000	14.4±0.11	27.9±2.03	−10.6±1.00	6.9±0.32	3.2±0.21
MAUS47R	81.4±3.02	−0.84±0.021	13.1±0.23	25.2±2.56	−8.9±0.69	6.1±0.33	0
MAUS47G	81.2±2.02	−0.45±0.014	12.9±0.51	25.2±1.07	−7.9±0.55	6.1±0.41	0.5±0.02
MAUS71R	84.4 ±2.36	−0.92±0.031	12.2±0.22	22.9±2.66	−3.3±0.66	4.4±0.95	0
MAUS71G	81.6 ±3.01	−0.5±0.012	12.0±0.19	23.4±3.01	−2.3±0.97	5.2±0.87	2.9±0.66
Tofu							
Commercial	80.1±3.33	3.05±0.33	18.8±2.36	39.5±5.65	−40.5±1.33	0	0
JS335 R	87.2±3.25	0.94±0.01	13.4±3.02	26.2±6.66	5.1±0.32	9.2^{a}±1.23	0
JS335 G	79.7±4.10	2.04±0.23	18.3±2.11	31.7±8.02	−39.2±0.33	1.22^{a}±0.69	9.0±0.99
DSb1 R	83.1±5.02	1.62±0.02	16.0±2.46	32.3±4.44	−18.4±1.02	4.32^{a}±0.87	0
DSb1G	78.8±3.98	2.67±0.32	16.5±1.98	35.6±7.02	−32.4±2.03	2.72^{a}±0.03	4.5±0.54
MAUS47 R	87.0±4.12	1.25±0.10	15.1±2.22	29.4±2.69	−3.6±1.14	8.02^{a}±0.25	0
MAUS47G	78.6±3.33	2.01±0.65	18.1±4.10	37.8±5.66	−41.5±2.66	3.42^{a}±0.12	5.4±0.44
MAUS71R	82.2±2.89	1.34±0.45	16.3±3.21	32.9±8.03	−22.8±1.03	3.72^{a}±0.99	0
MAUS71G	79.6±4.36	2.34±0.66	16.1±3.22	34.3±4.12	−28.3±1.05	2.82^{a}±0.11	2.8±0.45

R raw, *G* sprouted

ΔE1-commercial soymilk and tofu as reference

ΔE2-unsprouted soymilk and tofu as reference

[a] Significant between raw and sprouted soybean $P<0.5$

reduction otherwise necessitates intense heat (for TI) or methods like ultrafiltration (phytic acid). Since sprouting is a natural non-thermal non-chemical process it results in better quality-processed products like milk, tofu and okara.

Table 4 Sensory characteristics of Soymilk and tofu

Variety	Taste	Texture	Flavour	Colour	Appearance	Overall acceptability
Soymilk						
JS335 R	6.8±0.33	–	5.5±0.75	6.5±0.25	7.0±1.02	6.5±0.12
JS335 G	7.3±0.23	–	7.0±0.43	6.8±0.45	7.2±0.33	7.1±0.69
DSb1 R	6.3±0.95	–	5.9±0.66	6.6±0.48	7.1±0.59	6.5±0.33
DSb1G	7.0±0.16	–	6.7±0.68	6.7±0.69	7.1±0.74	6.9±0.48
MAUS47R	6.5±0.22	–	5.2±0.47	6.3±0.36	6.5±0.69	6.1±0.69
MAUS47G	7.3±0.25	–	6.9±0.56	6.3±0.47	6.6±0.56	6.8±0.78
MAUS71R	6.1±0.31	–	5.6±0.77	6.5±0.89	6.6±0.62	6.2±0.46
MAUS71G	6.9±0.44	–	7.0±0.95	6.8±0.22	6.8±0.36	6.9±0.39
Tofu						
JS335 R	7.5±0.45	6.3±0.23	6.5±0.45	6.6±0.59	6.8±0.55	6.7±0.49
JS335 G	8.0±0.19	6.0±0.33	7.3±0.78	6.5±0.77	6.7±0.46	6.9±0.77
DSb1 R	7.6±0.56	7.3±0.45	6.4±0.69	6.7±0.65	6.6±0.89	6.9±0.66
DSb1G	7.8±0.71	7.3±0.49	7.2±0.48	6.6±0.47	6.5±0.39	7.1±0.42
MAUS47 R	7.0±0.33	6.5±0.95	6.6±0.38	6.8±0.99	6.6±0.49	6.7±0.36
MAUS47G	7.6±0.45	6.4±0.23	7.5±0.48	6.8±0.16	6.8±0.56	7.0±0.48
MAUS71R	6.5±0.26	6.3±0.15	6.6±0.55	6.3±0.35	6.8±0.49	6.5±0.39
MAUS71G	7.0±0.66	6.3±0.78	7.0±0.89	6.3±0.36	6.7±0.65	6.7±0.44

R raw, *G* sprouted

Apart from improved nutritional profiles soymilk from sprouted beans had higher soymilk index (SMI) good colour characteristics and was found highly acceptable by panellists in sensory evaluation due to absence of beany flavour and odour. Similarly tofu from sprouted beans had higher tofu index, good colour and textural properties alongwith high acceptance on the 9-point hedonic scale. The improvements in composition and quality parameters was seen in all the varieties tested showing that sprouting could be beneficial for product development across varieties. The time and temperature used for production of soymilk was conventional (121 °C for 30 min). Evaluation of time and/temperature reductions could be tried out to reduce the heat requirement and intensity, which could result in better nutritional and functional quality products.

References

Achouri A, Boye JI, Zamani Y (2008) Soybean variety and storage effects on soymilk flavour and quality. Int J Food Sci Technol 43:82–90

Agrahar Murugkar D, Jha K (2009) Effect of sprouting on nutritional and functional characteristics of soybean (*Glycine max* L). J Food Sci Technol 46(3):240–243

AOAC (1984) Official methods of analysis. In: Association of Official Analytical Chemists, 12th edn. Washington DC

AOAC (1995) Official methods of analysis. In: Association of Official Analytical Chemists, 16th edn. Washington DC

Bharadwaj HL, Bhagsari AS, Joshi JM, Rangappa M, Sapre VT, Rao MSS (1999) Yield and quality of soymilk and tofu made from soybean genotypes grown at four locations. Crop Sci 39:401–405

Cai TD, Chang KC (1998) Characteristic of production-scale tofu as affected by soymilk coagulation method: propeller blade size, mixing time and coagulant concentrations. Food Res Int 31:289–295

Cai TD, Chang KC, Shih MC, Hou HJ, Ji M (1997) Comparison of bench and production scale methods for making soymilk and tofu from 13 soybean varieties. Food Res Int 30(9):659–668

Chantrapornchai W, Clydesdale F, Mc Clements DJ (1998) Influence of droplet characteristics on the colour of food emulsions. J Agric Food Chem 96(8):2914–2920

Chauhan OP, Chauhan GS (2007) Development of anti-nutrients free soy beverage using sprouted soybean. J Food Sci Technol 44:62–65

Collins JL, Sand GG (1976) Changes in trypsin inhibitory activity in some soybean varieties during maturation and sprouting. J Food Sci 41:168–172

Dave S, Yadav BK, Tarafdar JC (2008) Phytate phosphorus and mineral changes during soaking, boiling and sprouting of legumes and pearl millet. J Food Sci Technol 45:344–348

Egli I, Davidsson MA, Juillerat D, Barclay RF, Hurrel (2002) The influence of soaking and sprouting on the phytase activity and phytic acid content of grains and seeds potentially useful for complementary feeding. J Food Sci 67(9):3484–3488

Gesinde AF, Oyawoye OM, Adebisi A (2008) Comparative studies on the quality and quantity of soymilk from different varieties of soybean. Pak J Nutr 7(1):157–160

Gupta RP, Gupta RR (1990) Food processing in oxygen free environment, US Patent number 4915972

Hammerstrand GE, Black LT, Glover JD (1981) Trypsin inhibitor in soy products: modification of standard analytical procedures. Cereal Chem 15:215–218

Hsu D, Leung HK, Finney PL, Morad MM (1980) Effects of sprouting of nutritive value and baking properties of dry peas, lentils and faba beans. J Food Sci 45(1):87–92

Kakade ML, Simons N, Liner IE (1974) An evaluation of natural versus synthetic substrates for measuring the antitryptic activity of soybean samples. Cereal Chem 46:518–526

Kim WJ, Yoon SK, Leck CY (1986) Changes in oligosaccharides and sensory quality of soymilk during germination. Korean J Food Sci Technol 18(5):382–387

Kotwaliwale N, Bakane P, Verma A (2007) Changes in textural and optical properties of oyster mushroom during hot air drying. J Food Eng 78(4):1207–1211

Latta M, Eskin MA (1980) A simple and rapid colourimetric method for phytate determination. J Agric Food Chem 28:1313–1315

Lee CK, Karunanithy R (1990) Effects of sprouting on the chemical composition of Glycine and Phaselous beans. J Sci Food Agric 51:437–445

Luttrell WR, Wei LS, Nelson AT, Steinberg MP (1981) Cooked flavor in sterile Illinois soybean beverage. J Food Sci 46(2):373–376

Matsuura M, Obata A, Fukushima D (1989) Objectionable flavour of soymilk developed during soaking of soybeans and its control. J Food Sci 54:602–605

Mostafa MM, Rahma EH, Rady AH (1987) Biochemical and nutritional changes in soybean during sprouting. J Food Biochem 23:257–275

Nelson AI, Steinberg MP, Wei LS (1976) Illinois process for preparation of soymilk. J Food Sci 41:57–61

Oboh G (2006) Coagulants modulate the hypocholesterolemic effect of tofu (coagulated soymilk). Afr J Biotechnol 5(3):290–294

Ologhobo AD, Fetuga BL (1984) Distribution of phosphorus and phytate in some Nigerian variety of legume and some effects of processing. J Food Sci 49:199–201

Prabhakaran MP, Perera CO, Valiyaveettil S (2006) Effect of different coagulants on the isoflavone levels and physical properties of prepared firm tofu. J Food Chem 99(3):492–499

Ranganna S (1977) Handbook of analysis of quality control for fruits and vegetable products (2nd ed). New Delhi, Tata McGraw-Hill Publishing Co. Wiley, New York, pp 149–178

Wang CR, Chang SK (1995) Physicochemical properties and tofu quality of soybean cultivar proto. J Agric Food Chem 43:3029–3034

Weingartner K E (1987) Processing, nutrition and utilization of soybeans. In: Singh SR, Rachie KO, Dashiell KE (eds) Soybeans for the tropics. Wiley Chichester, pp 149–178