Evaluation of Milk and Cheese Making Quality of Soybean Varieties

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Abstract

Variety is one of the major factors that influence food from soybeans. This research was designed to evaluate milk and cheese making quality of eight popular soybean varieties. Standard methods of analysis were used to determine physicochemical characteristics of soymilk and cheese. Sensory qualities of milk and cheese prepared from different soybean varieties were evaluated using a five point hedonic scale. It was observed that soymilk and cheese yields of the varieties were in the range of 533-599% and 123-134%, respectively. The soymilk and cheese extracted from the different varieties were found to be significantly different for all physicochemical properties. In general, the milk and cheese samples had good nutritional composition and fell within acceptable limits for sensory quality attributes, indicating that all the eight soybean varieties used in this study can be potential sources for soymilk and cheese processing and substitution of dairy products.

Introduction

The unavailability of nutritious food and the high cost of animal protein are the main causes of protein-energy malnutrition in Ethiopia. In this regard, soybean (*Glycine max*) is an important world commodity due to its wider range of geographical adaptation, unique chemical composition, good nutritional value, functional health benefits and industrial applications. On average, dry soybean contains roughly 40% protein, 20% oil, 35% soluble (sucrose, raffinose, stachyose, etc.) and insoluble (dietary fiber) carbohydrates and 5% ash (Liu, 2004). Globally, the market for soybean-based foods is continuing to grow and researchers in many institutions are undertaking intensive plant breeding program to develop new and improved varieties that have quality traits for soymilk and cheese production (Achouri *et al*. 2005).

Soybean can be processed into many food products and cultivars with high protein content allow the production of foods with superior nutritional value and yield, such as soymilk and cheese (Schmutz *et al*., 2010; Liu, 1999), which are common forms of consumption of the crop in Ethiopia. Soymilk and cheese preparation generally includes blanching, soaking and grinding of soybeans in water, and filtering, boiling and coagulation of soymilk. At household level, soymilk is made by soaking the soybeans, grinding them in water, cooking the slurry and then filtering to remove sludge (Tangratanavale and Pan, 2003). Soybean *ayib*, one of the Ethiopian cottage type cheese also known as soybean curd similar to tofu, is made by coagulation of heated soymilk with a coagulant, followed by molding and pressing the cheese to drain away the liquid whey.

The yield, quality and texture of soymilk and cheese are influenced by many factors, such as variety of the crop (Chunmei *et al*., 2010; Walsh *et al*., 2010), processing method (Shih *et al*., 2006) and type and concentration of coagulant (Lim *et al.*, 2006). Thus, the objective of the current study was to evaluate milk and cheese making quality of eight popular soybean varieties in Ethiopia.

Materials and Methods

Plant materials

Beans of eight popular soybean varieties, namely, Gishama, Awassa-95, AFGAT, Tgx-13.3-2644, Nova, Belessa-95, Wegayen and Clark 63k were collected from Pawe Agricultural Research Center of the Ethiopian Institute of Agricultural Research.

Soymilk and cheese preparation

About 400 g cleaned bean of each soybean variety was blanched for 10 minutes in boiling water and soaked in 600 ml of tap water (1:3 soybean: water, w/v) overnight at room temperature. The swelled beans were drained, rinsed and de-hulled manually, then, wet-milled in a blender with hot tap water at a bean: water ratio of 1:8. The slurry was cooked with continuous stirring for 15 min, filtered using double layer muslin cloth. Half of the filtrate (soymilk) was again cooked for another 10 min to eliminate the cross contamination of microorganisms and cooled to room temperature for yield and physicochemical analysis of the soymilk. The remaining filtrate was lowered to 75 °C to prepare soy cheese. Then, 100 ml of filtered lemon juice was added to 1000 ml of soymilk and the mixture stirred in the same direction and kept until coagulated. The mixtures were then poured over muslin cloth and the liquid pressed out. Yield of the collected cheese was measured and samples were freeze dried for further analysis.

Determination of soymilk and cheese yield

Yield of soymilk was calculated based on weight of soymilk obtained and weight of soybean grain used to prepare the milk using the following formula.

$$\text{Yield of soymilk \%} = \frac{\text{weight of soymilk (g)}}{\text{weight of soybean (g)}} * 100$$

Similarly, yield of soy cheese was calculated based on weight of cheese obtained and weight of soybean grain used to make the cheese. The yield was calculated as described by Andika *et al.* (2011).

$$\text{Yield of soy cheese/tofu \%} = \frac{\text{weight of soy cheese/tofu (g)}}{\text{weight of soybean (g)}} * 100$$

Determination of pH and titratable acidity

The pH of soymilk was measured with a calibrated digital pH meter (model Jenway) by taking 10 ml of soymilk sample (Gesinde *et al*., 2008). The pH of the soy cheese was determined by mixing cheese and distilled water in the ratio of 1:1 by taking 10g of soy cheese and 10 ml of distilled water and, then, it was measured with a pH meter (Rehman and Fox, 2002). Titratable acidity, in terms of % lactic acid, was determined by modifying the procedure of Egan *et al*. (1987) and titrating 10 ml of soymilk sample against 0.1N NaOH using a 0.5% phenolphthalein indicator to an end point of faint pink color. Percent lactic acid was calculated as follows.

$$\text{Percent acidity (as lactic acid)} = \frac{0.009 \text{ X Vol. } 0.1 \text{ N NaOH}}{\text{Weight of the sample}} * 100$$

Proximate analysis

Soymilk and cheese samples were dried using freeze dryer and methods developed by Association of Official Analytical Chemists (AOAC, 2016) were used to determine crude protein, crude fat, crude fiber, and moisture and ash contents of the powders. Protein content was determined by Kjeldahl (Kjeltec 8400, Auto Sample Systems, Foss, Sweden) using N conversion factor of 6.25 following method 954.10, AOAC (2016). Soxhlet method (Soxtec 8000, Tecator Line, and Foss, Sweden) was used to estimate crude fat according to method number 2003.06, AOAC (2016). Moisture content was determined by air conviction oven drying method as described in 925.10, AOAC (2016). Ash was determined using the combustion method by a muffle furnace at 550 ^{o}C following the method described in 923.03, AOAC (2016).

Sensory evaluation

Soymilk and soy cheese were subjected to a sensory evaluation following the method of Kolapo and Oladimeji (2008). Thirty untrained panelists composed of males and females who were familiar with soymilk were selected for evaluation. The attributes considered for evaluation were color, aroma, taste, mouth feel and overall acceptability. Since the panelists were not trained, and to make the evaluation process consistent, a simple 5-point hedonic scale was used, where five stands for like very much and one for dislike too much, for each sensory attribute.

Statistical analysis

Data were subjected to analysis of variance using general Linear Model procedure of SAS software (SAS institute, 2002). The analysis for each parameter was done using triplicate samples and results were expressed as mean ± SD. Differences among means were accepted as statistically significant with P values < 0.05. Least significant difference (LSD) test was used to separate treatment means.

Results and Discussion

Physicochemical properties of soymilk

Soymilk samples were analyzed for milk yield, total solid, crude protein, crude fat, crude fiber, total ash, pH and lactic acid (Table 1). It was observed that soybean varieties showed significant differences ($P < 0.05$) for all physicochemical properties of soymilk, except for total solid content. Variety Clark 63k and Awassa 95 exhibited the highest and lowest soymilk yield, respectively. In line with this, Chunmei *et al*. (2010) and Walsh *et al*. (2010) have reported that yield, quality and texture of soymilk are highly influenced by variety of soybean. The soymilk yield recorded in the present study was also in agreement with the findings of Susu *et al.* (2013), who reported a range of 651.11±0.96 to 619.44±4.19% for non-germinated and germinated soybeans. The mean value of total solid content (5.55%) observed in the present study was comparable with the findings reported by Susu *et al.*, (2013) (5.86±0.39) and greater than the average value reported by Gesinde *et al.,* (2008) (3.78). As observed in the current study, Gesinde *et al.,* (2008) have also reported average moisture content of 96.22% for soymilk produced from different soybean varieties.

Similarly, crude protein content of soymilk samples significantly differed ($P < 0.05$), with the highest value for variety Clark 63k (57.59±2.70), followed by AFGAT (57.14±0.93) and Awassa-95 (56.57±0.13), while the lowest value for Nova (53.02±0.62). The average value of crude protein content (55.28%) recorded in the present study was higher than the value (40.3±0.62) reported by Ogbonna *et al*. (2013) for soymilk prepared using hot extraction method. On the other hand, the average value of crude fat content (19.73%) recorded in this study was similar to the findings of Ogbonna *et al*. (2013) (19.80±0.42) for soymilk made by hot extraction method. Soymilk sample extracted from variety Awassa-95 had the highest crude fiber content (0.85%), whereas that of variety Tgx-13.3-2644 had the least value (0.42%) (Table1). The average ash content estimated in the current study (4.12%) was similar to what has been observed in some previous studies (Ogbonna *et al*., 2013).

The pH of soymilk samples was in the range of 6.80 and 6.90. Similarly, Bansal and Kaur (2014) have reported a pH value of 6.85 to 7.05 for soymilk extracted from germinated and non-germinated soybeans. Furthermore, Gesinde *et al.*, (2008) have also reported a pH range of 6.57-6.70 for soymilk samples extracted from different varieties of soybean. The titratable acidity of soymilk samples varied slightly and the value ranged from 0.012% - 0.020% (Table 1).

Physico-chemical properties of soy cheese

Soy cheese samples extracted from different varieties were found to be significantly ($P < 0.05$) different for all physicochemical properties (cheese yield, moisture content, crude protein, crude fat, crude fiber, total ash and pH) (Table 2). In line with this, Chunmei *et al*. (2010) and Walsh *et al*. (2010) have indicated that yield, quality and texture of soy cheese were highly influenced by variety of soybeans. Accordingly, the cheese yield obtained in the present study (123-134%) significantly varied among soybean varieties and was in agreement with the findings of Gartaula *et al*. (2013) and

John *et al*. (2015). Gartaula *et al.* (2013) have also reported cheese yield of 126-147% using commercial coagulants, while John *et al.* (2015) have found an average cheese yield of 105%.

Crude protein content of tofu samples differed significantly and was in the range of 53-57% (Table 2). The highest value was recorded for cheese prepared from beans of variety AFGAT (57%) and the lowest was for variety Nova (53%). cheese protein content estimated in the present study was similar to some previously reported values (Sarani *et al*., 2014; Gartaula *et al*., 2013). Cheese extracted from different soybean varieties also showed significantly ($P < 0.05$) variations for fat, fiber and ash contents and for pH values, and these results were in agreement with the findings of Sarani *et al*. (2014), Gartaula *et al*. (2013), Ifesan and Oguntoyinbo (2012) and Nazim *et al.* (2013).

Table 1. Physicochemical properties of soymilk processed from different soybean varieties in Ethiopia

Soybean varietye	Yield (%)	Total Solid (%wb)	Protein (%db)	Fat (%db)	Fiber (%db)	Total Ash (%db)	pH	% LA
Gishama	555.87 ± 4.66^{cd}	5.15 ± 0.04^{a}	54.49 ± 1.33^{ab}	20.78 ± 2.25^{ab}	0.61 ± 0.01^{c}	4.24 ± 0.02^{ab}	6.86 ± 0.01^{b}	0.018 ± 0.001^{ab}
Awassa-95	532.51 ± 4.78^{f}	5.66 ± 0.28^{a}	56.57 ± 0.13^{ab}	20.51 ± 1.65^{abc}	0.85 ± 0.01^{a}	4.04 ± 0.02^{bc}	6.85 ± 0.01^{b}	0.02 ± 0.001^{a}
AFGAT	551.69 ± 4.14^{de}	5.26 ± 0.35^{a}	57.14 ± 0.93^{a}	16.34 ± 1.50^{cd}	0.59 ± 0.01^{d}	4.67 ± 0.42^{a}	6.84 ± 0.03^{b}	0.0165 ± 0.002^{b}
Tgx-13.3-2644	553.21 ± 4.31^{de}	5.27 ± 0.20^{a}	56.04 ± 3.01^{ab}	18.86 ± 1.96^{bcd}	0.42 ± 0.00^{f}	4.14 ± 0.14^{ab}	6.83 ± 0.01^{bc}	0.012 ± 0.002^{c}
Nova	569.22 ± 4.59^{b}	5.81 ± 0.53^{a}	53.02 ± 0.62^{b}	23.87 ± 3.06^{a}	0.43 ± 0.01^{f}	4.15 ± 0.11^{ab}	6.80 ± 0.01^{c}	0.0185 ± 0.001^{ab}
Belessa-95	565.41 ± 4.13^{bc}	5.67 ± 0.58^{a}	53.15 ± 0.78^{b}	21.77 ± 0.89^{ab}	0.71 ± 0.01^{b}	3.50 ± 0.33^{c}	6.90 ± 0.01^{a}	0.0175 ± 0.001^{ab}
Wegayen	544.00 ± 4.23^{e}	5.60 ± 0.50^{a}	54.22 ± 0.19^{ab}	20.82 ± 1.69^{ab}	0.48 ± 0.01^{e}	4.14 ± 0.18^{ab}	6.80 ± 0.01^{c}	0.0165 ± 0.001^{b}
Clark-63k	599.15 ± 4.70^{a}	5.97 ± 0.90^{a}	57.59 ± 2.70^{a}	14.85 ± 0.73^{d}	0.43 ± 0.01^{f}	4.11 ± 0.31^{b}	6.83 ± 0.01^{bc}	0.0185 ± 0.002^{ab}
Mean	558.88	5.55	55.28	19.73	0.56	4.12	6.84	0.02
CV (%)	0.80	8.82	2.86	9.38	1.54	5.74	0.24	8.36
LSD (α 0.05)	10.26	1.13	3.65	4.27	0.02	0.54	0.0382	0.0033

Means with the same letter in a column are not significantly different (P > 0.05); LA=Lactic Acid; CV=coefficient of variance; LSD=Least Significant Difference, wb=wet basis, db=dry basis

Table 2. Physicochemical properties of soy cheese processed from different soybean varieties in Ethiopia

Soybean varietye	Yield (%)	Moisture (%wb)	Total Solid (%wb)	Protein (%db)	Fat (%db)	Fiber (%db)	Ash (%db)	pH
Gishama	127.25 ± 1.65^{b}	73.57 ± 0.52^{bc}	26.44 ± 0.52^{ab}	55.43 ± 1.92^{abcd}	31.47 ± 1.50^{bc}	0.98 ± 0.03^{b}	2.02 ± 0.13^{abc}	3.93 ± 0.04^{c}
Awassa-95	125.08 ± 0.54^{b}	72.79 ± 0.92^{bc}	27.21 ± 0.92^{ab}	56.25 ± 1.03^{ab}	30.47 ± 0.86^{c}	0.77 ± 0.01^{cd}	2.06 ± 0.11^{abc}	4.11 ± 0.02^{b}
AFGAT	128.73 ± 1.83^{ab}	73.83 ± 0.04^{ab}	26.17 ± 0.04^{bc}	56.73 ± 2.93^{a}	27.92 ± 0.39^{d}	0.54 ± 0.01^{f}	2.06 ± 0.03^{abc}	4.04 ± 0.02^{bc}
Tgx-13.3-2644	123.79 ± 2.80^{b}	74.93 ± 0.12^{a}	25.07 ± 0.12^{c}	53.49 ± 0.80^{cd}	31.81 ± 0.71^{bc}	0.58 ± 0.01^{e}	1.93 ± 0.11^{bc}	4.14 ± 0.02^{b}
Nova	134.03 ± 4.16^{a}	72.97 ± 0.17^{bc}	27.03 ± 0.17^{ab}	53.04 ± 0.77^{d}	33.88 ± 0.24^{a}	0.74 ± 0.01^{d}	1.91 ± 0.03^{bc}	4.11 ± 0.11^{b}
Belessa-95	123.35 ± 2.79^{b}	73.77 ± 0.58^{ab}	26.24 ± 0.58^{bc}	54.27 ± 0.85^{bcd}	32.68 ± 0.75^{ab}	1.13 ± 0.01^{a}	1.81 ± 0.04^{c}	4.07 ± 0.05^{b}
Wegayen	127.05 ± 1.28^{b}	73.20 ± 0.56^{bc}	26.80 ± 0.56^{ab}	55.28 ± 0.13^{abcd}	31.06 ± 0.23^{c}	0.36 ± 0.01^{g}	2.14 ± 0.11^{ab}	4.13 ± 0.06^{b}
Clark-63k	127.16 ± 4.05^{b}	72.45 ± 0.70^{c}	27.55 ± 0.70^{a}	55.77 ± 0.14^{abc}	31.23 ± 0.89^{c}	0.78 ± 0.01^{c}	2.22 ± 0.19^{a}	4.27 ± 0.02^{a}
Mean	127.05	73.44	26.56	55.03	31.32	0.73	2.02	4.10
CV (%)	2.08	0.74	2.03	2.51	2.55	2.10	5.29	1.29
LSD (α 0.05)	6.08	1.25	1.25	2.39	1.38	0.04	0.25	0.12

Means with the same letter in a column are not significantly different ($p > 0.05$); CV=coefficient of variance; LSD=Least Significant Difference; wb=wet basis, db=dry basis.

Sensory evaluation of soymilk and cheese

The sensory responses of soymilk and cheese prepared from different soybean varieties are presented in Table 3 and 4. In general, the milk and cheese samples were within acceptable limits, indicating milk and cheese making potential of all the soybean varieties used in the current study. Except for aroma of cheese, where the difference was not significant, all sensory attributes showed significant difference between the varieties ($P<0.05$). In line with this, it has been reported that sensory quality of soymilk and cheese is affected by many factors, such as genotype of soybean, processing method and environmental conditions (Min *et al.*, 2005 and Terhaag *et al.*, 2013). Besides, seed color of soybean, which is in fact genotype dependent factor, may also affect the color of products (Antarlina *et al.*, 2002), as white or creamy white color is the desirable soymilk and cheese characteristic (Hou and Chang, 2004).

In the present study, soymilk from variety Gishama and AFGAT had better acceptability in terms of color. Texture score value of the soy cheese ranged between 3.4 and 3.9 (Table 4). In line with this, it has been reported that coherent, smooth and firm textures are preferred types of soy cheese, whereas hard and rubbery is not desirable. Such characters are also related to the fat content where higher fat in cheese makes the protein link weaker, entrap more water and makes them softer (Poysa and Woodrow, 2002). In general, based on the mean values of the entire sensory attributes, it was observed that soymilk obtained from variety AFGAT and cheese obtained from Clark-63k and Wegayen were most preferred.

Table 3. Sensory scores (1-5 scale) of soymilk prepared from different soybean varieties.

Soybean varietye	Color	Aroma	Taste	Mouth Feel	Overall Acceptability
Gishama	3.67 ± 1.09^{a}	3.13 ± 1.11^{bcd}	3.17 ± 0.99^{ab}	3.27 ± 0.87^{a}	3.40 ± 1.00^{ab}
Awassa-95	3.13 ± 0.94^{bc}	3.10 ± 0.96^{cd}	3.07 ± 1.01^{abc}	3.13 ± 1.07^{ab}	3.20 ± 1.00^{b}
AFGAT	3.57 ± 0.86^{a}	3.53 ± 0.94^{a}	3.40 ± 0.97^{ab}	3.37 ± 0.89^{a}	3.57 ± 0.94^{a}
Tgx-13.3-2644	2.80 ± 0.96^{d}	2.97 ± 0.89^{d}	2.67 ± 0.88^{c}	2.87 ± 0.82^{b}	2.80 ± 0.85^{c}
Nova	3.23 ± 0.86^{b}	3.33 ± 1.03^{abc}	3.00 ± 0.95^{bc}	3.10 ± 0.92^{ab}	3.40 ± 0.93^{ab}
Belessa-95	3.10 ± 0.88^{bc}	3.43 ± 0.97^{ab}	3.17 ± 0.95^{ab}	3.20 ± 0.89^{a}	3.47 ± 0.90^{ab}
Wegayen	2.93 ± 0.94^{cd}	3.33 ± 0.99^{abc}	3.43 ± 0.97^{a}	3.33 ± 0.96^{a}	3.50 ± 0.97^{ab}
Clark-63k	3.27 ± 1.05^{b}	3.17 ± 1.05^{bcd}	3.33 ± 0.99^{ab}	3.27 ± 1.01^{a}	3.27 ± 0.94^{ab}
Mean	3.21	3.25	3.15	3.19	3.33
CV (%)	5.25	5.43	7.26	5.78	6.24
LSD (α 0.05)	0.30	0.31	0.40	0.32	0.36

Means with the same letter in a column are not significantly different ($P > 0.05$); CV=coefficient of variance; LSD=Least Significant Difference.

Table 4. Sensory scores (1-5 scale) of soy cheese prepared from different soybean varieties

Soybean varietye	Color	Flavor	Taste	Texture	Overall Acceptability
Gishama	3.53±1.20[ab]	3.47±0.94[a]	3.50±0.86[c]	3.73±0.83[ab]	3.70±1.02[b]
Awassa-95	3.57±1.07[ab]	3.43±1.04[a]	3.43±0.94[c]	3.50±1.07[b]	3.87±0.94[ab]
AFGAT	3.83±0.95[a]	3.60±1.00[a]	3.63±0.81[bc]	3.50±1.11[b]	3.93±0.87[ab]
Tgx-13.3-2644	3.63±1.13[ab]	3.67±0.76[a]	3.70±0.84[abc]	3.70±0.99[ab]	3.73±1.01[b]
Nova	3.50±1.14[ab]	3.53±0.94[a]	3.60±0.97[bc]	3.40±0.93[b]	3.63±1.07[b]
Belessa-95	3.27±1.14[b]	3.43±1.01[a]	3.53±1.01[bc]	3.67±0.99[ab]	3.60±1.07[b]
Wegayen	3.87±1.04[a]	3.63±0.96[a]	4.00±0.53[a]	3.87±0.86[a]	3.90±0.99[ab]
Clark-63k	3.43±1.22[ab]	3.47±1.04[a]	3.83±0.83[ab]	3.93±0.91[a]	4.17±0.65[a]
Mean	3.58	3.53	3.65	3.66	3.82
CV (%)	7.33	7.12	5.15	5.53	5.25
LSD (α 0.05)	0.46	0.44	0.33	0.35	0.35

Means with the same letter in a column are not significantly different ($p > 0.05$); CV=coefficient of variance; LSD=Least Significant Difference.

Conclusion

Physicochemical properties and sensory quality of soymilk and cheese significantly ($P < 0.05$) varied with soybean varieties. In general, all the milk and cheese samples had good nutritional composition and fell within acceptable limits, indicating that the eight soybean varieties used in this study can potentially be used for soymilk and cheese processing and, thus, substitution of dairy products.

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