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Development of Non Dairy Milk Alternative Using Soymilk and Almond Milk

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Abstract

Non dairy milk alternative represents the milk substitute for people suffering from milk intolerance and allergy. The present study was thus carried out to standardize the process for development of plant based milk alternative using soymilk and almond milk. Formulations for manufacture of soymilk and almond milk were optimized on the basis of their sensory as well as nutritional properties. Optimized milks were thereafter blended for the preparation of different non dairy milk alternatives in different ratios as T_{01} (soymilk), T_{02} (almond milk), T_1 (60% soymilk + 40% almond milk), T_2 (50% soymilk + 50% almond milk), T_3 (40% soymilk + 60% almond milk) while cow milk (T_0) served as control. The soymilk, almond milk and the blends of both were analysed for their proximate as well as sensory properties. Among the plant based milks, soymilk displayed higher moisture, pH and protein content while the values of total solids, titratable acidity, ash, fat, iron and calcium were higher for almond milk. Sensory score revealed that soy-almond milk blend prepared with 60% almond milk and 40% soymilk was recorded highest of all the milks analyzed. The selected milk blend (T_3) though had lower sensory score than control but rated quite good in terms of acceptability. With regards to nutrient profile of milk blend in comparison to control, the results indicated that concentration of all the nutrients were higher in milk blend (T_3) except for Ca & protein which were recorded higher in control. Therefore, based on nutrient and sensory profile, it can be implied that soy almond milk blend suits well as a candidate for use as non dairy milk alternative

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Introduction

Milk is one of the most commonly consumed food item relished by human population since ages due to its nutritional value and its versatility in satiating appetite. However, nowadays its consumption has raised concerns among the health conscious and risk prone population as clinical studies have demonstrated that some constituents of milk are

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associated with deleterious health effects such as cow milk allergy (CMA), lactose intolerance (LI), anaemia and coronary heart diseases[1,2,3]. Plant based milk may be a good choice for people looking for dairy free alternatives. For this reason, consumers have become more interested in preferring vegan diets over normal mammalian milk[4].

Plant-based milks essentially lack certain components normally associated with mammalian milk such as cholesterol, saturated fatty acids, antigens and lactose while on the same time being the good source of minerals, non allergic proteins, essential fatty acids etc., making it well suited to serve as dairy free alternative. In recent years, plants sources have been accepted as functional foods and nutraceuticals as they are rich source of health beneficial bioactive components like minerals, vitamins, dietary fibres and antioxidants[5]. Legumes and nuts have those characteristics that make them convenient to combine them to produce dairy-free nutritious, health promoting, economical and palatable plant based milk alternative.

Soybean (Glycine max) is one of the most widely grown as well as consumed legume across the world due to its remarkable nutrient profile. It not only contains high quality protein comprising of almost all essential amino acids with highly digestibility (92-100%) but also is rich source of minerals such as calcium, potassium, magnesium, iron, zinc and copper. The presence of high levels of dietary fibre (35%) (both soluble and insoluble) makes it useful for diabetic patients and individuals on weight control diet. Soybean possesses healthy fat profile in terms of fatty acids with the levels of unsaturated fatty acids like polyunsaturated fatty acids (PUFA) being high and saturated fatty acids (SAFA) being low; lending high ratio of PUFA to SAFA (82:18)[6] to soy. Consumption of soybean and soy foods has been related with cardioprotective attributes due to high ratio of unsaturated fatty acids (omega-3 & omega-6), presence of phytosterols and high levels of tocopherols[7,8]. Being rich source of aforementioned compounds; B vitamins and isoflavones, soybean has been demonstrated to carry therapeutic properties in treating many chronic diseases like osteoporosis, cancers, cardiovascular diseases[9,10].

Almond (Prunus dulcis) is one of most popular and highly consumed of all the nuts[14]. High consumption rate among the humans is probably due to its well known medicinal properties such as healthy lipid profile, immune enhancing and antioxidant effects. Almond is a concentrated source of nutrients and is a remarkable source of α-tocopherol (36.4%) which plays a pivotal role in fighting against free-radical reactions and, hence, prevention of oxidative stress[11,12]. In addition to being enriched with minerals like magnesium (19.5%), copper (16.0%), phosphorus (13.4%), it also possesses high fibre content (13.2%). Almond contains approximately 25% of protein with exceptionally high levels of arginine, and majority of protein is present in the form of AMP or amandin[13]. The fat content of almond is quite high (49.4% of weight) but is particularly characterized by high level of MUFA (67%) which is potentially beneficial for heart health. Furthermore, almonds also contain polyphenols and phytosterols such as β-sitosterol, stigmasterol, campesterol, sitostanol and campestanol which possess cardioprotective attributes[14].

Plant-based milk alternatives are fluids derived from maceration of plant material soaked in water and comminution to a size range of 5-20 µm through homogenisation such that mammalian milk is simulated in appearance and consistency. Soy milk and almond milk are rich creamy milky white liquid which display similarities to cow milk in appearance and consistency. While soy milk has been utilised in many products like soy cheese, soy yogurt, tofu[15,16], the main constraint in its utilization is its typical beany flavour which is overcome by either fermentation or through addition of flavours or additives to mask the flavour[17]. Therefore, taking into account sensorial attributes of soy milk and economical constraints associated with almond milk, both could be blended together to overcome the limitation associated with the individual milks. Thus the present study was undertaken to optimize the formulation for developing soy-almond milk blend for obtaining non dairy milk alternative.

Materials and Methods

Raw Material

Almonds and yellow soybeans were purchased from a local market in Rohtak, Haryana. A few seeds and nuts with defects were removed from the samples.

Preparation of Soymilk

Soymilk Making Protocol

Soy milk was prepared by soaking soybeans for 12 h in 0.5% $NaHCO_3$ solution and draining the alkali solution afterwards. It was then boiled again in fresh 0.5% $NaHCO_3$ solution for 30 min which was drained again followed by grinding of soybean in water (in optimized ratio) at room temperature. The soy-slurry was then heated to 90˚C and filtered to remove okara.

Optimization of Level of Bean Water in Soy Milk

Level of bean and water to be used in preparation of soy milk was optimized on the basis of preliminary trials using soybean and water in different ratios (1:1; 1:2 and 1:3) and adjudging the most suitable one based on nutritional and sensory profile (Table 2). The most acceptable ratio in all the physico-chemical analysis was 1:1 as it had highest nutritional value among all the combinations. The beany flavour revealed in sensory analysis was permissible with the presumption that it would be later overcome by blending with almond milk during optimization trials.

Preparation of Almond milk

Almond milk making protocol

For preparation of almond milk, almonds were soaked in distilled water for 12 h followed by draining and dehulling steps. The dehulled almonds were ground with water in a blender in optimized ratio for 2 min. The obtained slurry was strained through a two layer muslin cloth to obtain almond milk.

Optimization of Ratio of Nut: Water in Almond Milk

The optimization of level of nut and water to be used in preparation of almond milk was carried out on the basis of preliminary trials using different ratios of nut and water (1:1; 1:2 and 1:3) followed by the evaluation of most suitable ratio based on nutritional and sensory attributes. The ratio 1:1 was found more acceptable as it indicated higher nutritive value (ash, protein and fat content) for physico-chemical characteristic and imparted better mouth feel in sensory analysis as compared to other two ratios.

Preparation of Soy-Almond Milk Blend

Different soy almond milk blends were prepared by mixing soymilk and almond milk in different proportions as given in Table 1.

Table 1: Combination of soymilk and almond milk in different proportions

Treatments	Almond milk	Soymilk
T_0*	–	–
T_{01}	–	100%
T_{02}	100%	–
T_1	40%	60%
T_2	50%	50%
T_3	60%	40%

*cow milk was taken as control (T_0).

Chemical Analysis

The samples were analyzed for moisture content, total solids content and ash content as per standard methods described in AOAC[18]. Protein content was determined by standard Kjeldahl method described in AOAC[19]. Fat content was estimated by Gerber Method BIS[20]. Mineral content (calcium & iron) was estimated by AAS method given by AOAC[21]. Titratable acidity was estimated by titrating against 0.1N NaOH as per AOAC[18] method.

Sensory Evaluation

Sensory evaluation of soy-almond milk was carried out in triplicate using 9-point Hedonic scale by a panel of 10 semi trained judges. Different milk samples were evaluated for their colour, mouthfeel, taste, flavour and overall acceptability

Statistical Analysis

The data from triplicate observations were analyzed statistically using one factor analysis of variance (ANOVA) with subsequent least significant difference (LSD) using OPSTAT version OPSTAT 1.exe (Hisar).

Results and Discussion

Optimization of Soymilk Formulation (Bean: Water Ratio)

For optimization of formulation of soymilk, three different ratios of bean: water were evaluated i.e. 1:1; 1:2 and 1:3. The different combinations obtained thereof were analyzed for both proximate composition and sensory attributes.

Protein, ash and fat content in soymilk (1:1) were 3.24%, 0.87% and 2.35% respectively and showed significantly higher ($p<0.05$) values than the soymilks (1:2) & (1:3) which displayed the corresponding values as 2.39%, 0.60%, 1.43% and 1.27%, 0.43%, 0.76% respectively. Protein content in present study agrees well with several previous reports[22,23] in case of soymilk. Similarly fat and ash content in present study are in alignment with those reported in previous studies for 1:3 ratio[23,24]. Among the different ratios analyzed for nutritive value (Table 2), it is evident that nutritive value was highest for combination (1:1) owing to least amount of dilution involved in the formulation. While sensory analysis of this combination revealed that beany flavour was more pronounced in soymilk prepared with equal ratios of water and bean and it was found to be almost absent in case of soymilk with ratio 1:3. However, the soymilk (1:1) was selected for further studies considering the fact that it had highest nutritional value of all the combinations and any beany flavour which may be perceived poor in acceptability would later be overcome by blending with almond milk during optimization trials.

Table 2: Proximate composition of soymilk and almond milk in different ratios

Milk type	Ratio Composition	1:3 (w/v)	1:2 (w/v)	1:1 (w/v)
Soymilk	Moisture (%)	97.513±0.038^{c}	94.990±0.026^{b}	91.897±0.032^{a}
	Ash (%)	0.430±0.012^{a}	0.603±0.018^{b}	0.870±0.017^{c}
	Fat (%)	0.763±0.015^{a}	1.430±0.040^{b}	2.347±0.015^{c}
	Protein (%)	1.273±0.026^{a}	2.390±0.038^{b}	3.240±0.036^{c}
Almond milk	Moisture (%)	86.080±0.043^{c}	78.437±0.048^{b}	72.117±0.043^{a}
	Ash (%)	1.630±0.046^{a}	2.403±0.035^{b}	3.020±0.049^{c}
	Fat (%)	3.833±0.043^{a}	6.127±0.049^{b}	8.257±0.048^{c}
	Protein (%)	0.768±0.048^{a}	0.972±0.023^{b}	1.380±0.040^{c}

Data are presented as mean±SEM (n=3). Means within rows with different superscripts letters are significantly different ($p<0.05$) from each other

Optimization of Almond Milk

The optimization of almond milk was done by varying the ratio of nut: water (1:1, 1:2 & 1:3) leading to different combination for preliminary trials. The evaluation of adequacy of different formulations of almond milk was carried out on the basis of both nutritional attributes as well as sensory profile. Ash, fat and protein content in almond milk (1:1) were 3.02%, 8.25%, 1.38% respectively and showed significantly higher values ($p<0.05$) than almond milk in ratios (1:2) and (1:3). The values for almond milk (1:2) & (1:3) were 2.40%, 6.12%, 0.97% and 1.63%, 3.83%, 0.76% respectively (Table 2). Yetunde et al[24] reported a 3.40% fat level in almond milk with 1:3 ratio which is quite close to the value obtained in present study for the same ratio. Yetunde et al[24] observed the similar results of fat and ash content in almond milk. Nutritional value was found to be highest for the combination (1:1), on account of being least diluted of all the ratios analyzed.

Furthermore on subjecting the different combinations to sensory analysis, it was seen that almond milk (1:1) displayed a better mouthfeel as compared to the other two ratios which carried watery after taste

Physicochemical Characteristics of Soymilk and Almond Milk

The results regarding physicochemical characteristics of soymilk and almond milk are presented in Table 3. Significant differences ($p<0.05$) were observed among the samples for all the parameters evaluated except for pH. Ash content as analyzed in samples varied from 3.023% to 0.807% for almond and soymilk respectively and was recorded higher for almond milk. Ash content in present study is in alignment with previous findings of Berryman et al[14] for soymilk. Protein content in almond milk was 1.308% and was comparatively lower than soymilk with a protein content of 3.174%. Higher relative amount of moisture content was noted for soymilk (91.89%) as compared to almond milk (72.04%). Fat content in almond milk was observed to be almost fourfold higher than soymilk. Similar value of ash content has been reported for soymilk by Yetunde et al[24]. Bansal and Kaur[22] observed similar fat content in soymilk in their study.

Table 3: Physicochemical characteristics of soymilk and almond milk

Parameters	Soymilk (%)	Almond milk (%)
Moisture	91.890 ± 0.591^{b}	72.040 ± 0.301^{a}
Titratable Acidity	0.099 ± 0.003^{a}	0.390 ± 0.003^{b}
pH	7.395 ± 0.005^{b}	6.920 ± 0.010^{a}
Total solids	8.110 ± 0.591^{a}	27.960 ± 0.301^{b}
Ash	0.807 ± 0.009^{b}	3.023 ± 0.009^{a}
Iron (mg/100ml)	1.587 ± 0.010^{a}	3.980 ± 0.005^{b}
Calcium (mg/100ml)	5.970 ± 0.010^{a}	16.010 ± 0.010^{b}
Fat	2.350 ± 0.050^{a}	8.250 ± 0.100^{b}

Data are presented as mean±SEM (n=3). Means within rows with different superscripts letters are significantly different ($p<0.05$) from each other.

Physico-Chemical Properties of Different Milk Blends

The results obtained regarding different physico-chemical properties of control and different combinations of milk samples are presented in Table 4. Moisture content of samples varied from 72.040% to 91.890 % and displayed significant difference ($p<0.05$) among all the milk samples analyzed. Moisture content was recorded highest for soymilk (91.890%) followed by control (86.50%) while lowest value was observed for almond milk. Milk blends prepared with higher proportion of almond milk progressively displayed lower moisture content as almond milk contained higher total solids content. Yetunde et al[24] reported the higher moisture content of almond milk as 86.11% and this can be attributed to higher level of dilution used (1:3) for milk preparation in their study. Result for moisture content in soymilk agrees well with that of Tripathi et al[23] for soymilk

The ash content of different milk blends T_{01} (soymilk), T_{02} (almond milk), T_1 (60% soymilk + 40% almond milk), T_2 (50% soymilk + 50% almond milk) and T_3 (40% soymilk + 60% almond milk) were recorded as 0.807%, 3.023%, 1.063%, 1.937% and 2.367% respectively while ash content of T_0 (control) was noted as 0.717%. Ash content varied significantly ($p<0.05$) in all the milk blends except for T_0 and T_{01}. Ash content observed for cow milk and soymilk was almost identical. It can be implied from the readings obtained that almond milk had the highest ash content followed by T_3 and least value of all was recorded for control (cow milk). The results clearly indicated that the control (cow milk) contained lower mineral content as compared to other milk blends which is important observation from nutritional point of view. The soymilk also contained lower mineral value than almond milk. The values obtained for ash content for almond milk in the present study is in alignment with the value reported earlier Yetunde et al[24].

The protein content of all the samples varied significantly ($p<0.05$) and differed from 1.308% to 3.290%. Treatment T_0 (control) and T_{01} contained more protein content than others. The low protein content in almond milk (1.308%) might be due to the low solubility of almond proteins in water, consequently leading to poor extraction of nut proteins in milk. The decrease in protein content in almond milk may also be due to high fat content in milk which interferes with the solubility of the proteins[17]. From the observations, it is evident that as amount of almond milk increased, protein content of blends decreased correspondingly. The findings of protein content of almond milk are in agreement with the finding of Yetunde et al[24] who reported that almond milk contained 1.38% proteins. The results of protein content in soymilk are in conformation with those reported by Afoakwa et al[25].

Fat content of control and different combinations of milk samples revealed significant differences ($p<0.05$) among treatments. Treatment T_{02} and T_3 had comparatively higher fat content than others. Treatment T_{01} contained lowest fat content while T_0 (control) had next lower level. As the amount of almond milk increased in blends, the fat content increased correspondingly. Yetunde et al[24] also reported fat content in almond milk similar to the present study. The fat content of soymilk is in agreement with the findings of Nande et al[15] who reported 2% fat in soymilk.

Mineral content varied significantly ($p<0.05$) among different milk blend samples (Table 4). Control milk had the highest content of calcium and lowest content of iron compared to all the milks. Among the plant milks, almond milk contained higher mineral content (both Ca and Fe) compared to soy milk and thus as the level of almond milk increased in the blends, so did the mineral content. Mineral content for soy milk (0.85%) was in similar range of that reported by Nande et al[15]. The findings for mineral content in present study for almond milk are comparable to those reported by Yetunde et al[24].

The titratable acidity was found to be significantly different ($p<0.05$) for all the samples except for treatments T_2 and T_3 which were found to be identical. Treatment T_{01} had the lowest titratable acidity than other treatments including control (T_0). The titratable acidity of soymilk is in agreement with the findings of Gakkhar et al[27]. Bernat et al[26] studied the effect of processing on almond milk and observed the titratable acidity of almond milk 0.39%

Table 4: Chemical composition (%) of different milks and milk blends

	T_0	T_{01}	T_{02}	T_1	T_2	T_3
Ash	0.717 ± 0.009^a	0.807 ± 0.009^a	3.023 ± 0.009^e	1.063 ± 0.009^b	1.937 ± 0.015^c	2.367 ± 0.088^d
Protein	3.290 ± 0.006^c	3.174 ± 0.066^c	1.308 ± 0.013^a	2.935 ± 0.005^b	2.785 ± 0.005^b	2.435 ± 0.015^b
Fat	4.380 ± 0.006^b	2.350 ± 0.050^a	8.250 ± 0.100^f	5.650 ± 0.050^c	6.550 ± 0.050^d	7 .100 ± 0.100^e
Moisture	86.503 ± 0.023^e	91.890 ± 0.591^f	72.040 ± 0.301^a	83.370 ± 0.591^d	80.910 ± 0.519^c	78.285 ± 0.564^b
Calcium (mg/100 g)	107 ±0.009^a	5.970 ± 0.010^b	16.010 ± 0.010^f	8.485 ± 0.005^c	10.620 ± 0.010^d	12.725 ± 0.005^e
Iron (mg/100g)	0.070 ± 0.006^a	1.587 ± 0.010^b	3.980 ± 0.005^d	1.870 ± 0.010^b	2.747 ± 0.009^c	3.070 ± 0.010^c
Total solids	13.497 ± 0.023^b	8.110 ± 0.591^a	27.960 ± 0.301^f	16.630 ± 0.519^c	19.090 ± 0.519^d	21.715 ± 0.564^e
Titratable acidity (%)	0.180 ± 0.006^b	0.099 ± 0.003^a	0.380 ± 0.003^e	0.273 ± 0.009^c	0.297 ± 0.003^d	0.326 ± 0.003^d

Data are presented as mean±SEM (n=3). Means within rows with different superscripts letters are significantly different ($p<0.05$) from each other

Sensory Evaluation

Sensory profile is the most important characteristic that contributes to overall quality of a product. It is the property by which consumer first identifies and associates his likeability to a particular product. The sensory evaluation of freshly prepared milk blends was done using a nine point hedonic scale (Table 5). All the milk blends were compared with the cow milk (control). The almond milk sample (T_{02}) was found to be most acceptable followed by T_3 and T_2 respectively. The mouthfeel of treatment T_{02}, T_2 and T_3 scored higher than others. The better mouthfeel may be attributed to the higher fat content of the samples and fat is known to be associated with good mouthfeel. The lowest score for colour, mouthfeel and taste was scored for T_{01}. The high proportion of almond milk in blends may have improved the colour, taste and mouthfeel in blends resulting in higher overall acceptability. Therefore, T_3 blend had highest overall acceptability score compared to other milk blends though it had lower O. A. as compared to control milk (8.7 vs. 8.2).

Table 5: Sensory evaluation of different milk blends

Treatments	colour	flavour	mouthfeel	Overall acceptability
T_0	8.200±0.153^d	8.533±0.120^e	8.400±0.058^e	8.733±0.088^f
T_{01}	6.567±0.145^a	6.657±0.120^a	6.467±0.088^a	6.567±0.088^a
T_{02}	8.467±0.088^f	8.367±0.088^d	8.500±0.033^f	8.467±0.033^e
T_1	7.233±0.088^b	7.433±0.088^b	7.533±0.115^b	7.367±0.088^b
T_2	8.133±0.088^c	8.037±0.033^c	8.200±0.033^c	8.067±0.033^c
T_3	8.343±0.120^e	8.147±0.033^c	8.367±0.115^d	8.200±0.058^d

Data are presented as mean±SEM (n=3). Means within columns with different superscripts letters are significantly different ($p<0.05$) from each other

Conclusion

Based on analysis of control milk and milk blends used in this study, it can be concluded that plant based milk prepared by combination of soymilk and almond milk can be a good alternative of cow milk due to absence of lactose and allergens and with better nutritional as well as sensory profile. Since it was a pilot scale study for the non dairy milk alternative, further modifications with respect to addition of emulsifiers, sweeteners and other additives may be carried for the commercialization of product

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