PRELIMINARY STUDY ON THE PRODUCTION AND CHARACTERIZATION OF LEGUMES BASED MILK CHOCOLATE FOR USE AS A DAIRY MILK SUBSTITUTE

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ABSTRACT

The present study was carried out to standardize the production of legumes based milk chocolates and evaluate the acceptability of these chocolates. Among the plant based legumes-milk, soy-bean (SB) milk and yellow-pea (YP) milk exhibits higher moisture content, protein, minerals and vitamins, whereas peanut (PN) milk contains a high amount of carbohydrates, fats and folic acid. In addition, jaggery was used instead of sugar for its rich source of carbohydrates and vitamin C. Chocolates were produced at four ratios, namely 1:1, 1:2, 1:3 and 1:4 with PN:YP and PN:SB, and favoured on the basis of their sensory as well as physico-chemical properties. Carbohydrates and fats serve as a main source of energy, the 45% of carbohydrates and 30.7% of fats in PN: SB milk chocolate relatively represents a high energy source and gives better mouth feel. Among the produced legumes-based milk chocolates, sodium and potassium were higher in PN:SB milk chocolates than those in PN:YP milk chocolates. Furthermore, chocolates produced at 1:2 and 1:1 ratios had good flavour, taste, texture, colour and overall acceptability for PN:SB and PN:YP respectively, and the average scores of each attribute were represented in radar charts.

Keywords: Leguminous chocolate,Milk alternatives,Soy-Bean, Yellow-Pea, Peanut, Sensory analysis.

1. INTRODUCTION

Chocolate ranks the first among all the confectionary products in the world because of its pleasant flavor and taste, which leads the majority of consumers to adore chocolate as the common food product[1]. All food products made out of cows' milk is appreciably more nutritious, and the milk chocolate is considered to be a wholesome confectionery food and distinct by its measurable properties and unfalteringly by consumer liking [2]. However, cows' milk has some limitations in human health, such as lactose intolerance, high cholesterol, saturated fat content and allergenicity [3]. Recently plant based legumes-milk was used as the substitute for cows' milk to produce value-added food products with the responsiveness of nutritional benefits [3],[4], and as a non-dairy milk alternative for people suffering from milk intolerance and allergy. Legumes such as cowpeas, lentils, soybeans, peanuts, and other podded vegetables provide a wide-range of essential nutrients including protein, low glycemic index, carbohydrates, dietary fiber, minerals, vitamins, and folate, which are health promoting vital components for a healthy life [5]-[7]. In addition, protein and protein- derived bioactive peptides of legumes have significant roles as health-enhancing compounds [8], and they possibly will contribute to increase the nutrients in processed food [9],[10]. They can be also used as a good source of folic acid and folates, which decreases the risks of preterm delivery, low birth weight, fetal growth retardation, and developmental neural tube defects [11],[12]. Legumes help to lower cholesterol, triglycerides, inflammation, blood pressure, and cardiovascular disease as leguminous fibers are hypoglycosuria because they contain more amylase than amylopectin [13]-[15].

Peanut milk a good substitute for cows' milk, and it is obtained by soaking the full fat raw peanuts with water followed by grinding and filtering the slurry produced. It has a high nutritional value and a wide variety of milk based products such as yoghurt, butter milk, ripened cheese and tofu, which are obtained from fermentation [16],[17]. Soybean milk is obtained as off-white creamy milk by soaking, grinding and filtering soybeans [18]. It contains proteins, fats, carbohydrates, calcium, iron, sodium, carotene, vitamin E, riboflavin, etc., [19]. Green and beany flavor limits the application of soybean milk in food products; moreover pasteurization at 85°C or below will extend the application limits of soybean milk. It is reported that milk from soybean contains a high content of nutrients thus solving the problem of protein-calorie malnutrition [20]-[22]. Yellow-peas have been part of the human diet because of their wide availability and low cost. They are also used as important sources of high-quality proteins, starch, dietary fiber, minerals and vitamins. In addition, peas contain a wide range of phytochemicals with known bioactivity and potential health effects [23].

Legumes provide vast opportunities to be utilized in processed foods such as bakery products, bread, pasta, snack foods, soups, cereal bar filing, tortillas, and meat, their high nutrition content. For the same reason it seems to be ideal for inclusion in designing snack, baby, and sports foods [24]. Some studies have reported that the presence of high saponin and phytosterol contents in legumes reduces the formation of low serum cholesterol and low-density lipoprotein cholesterol, which is negatively associated with coronary heart disease [13],[15],[25]. The consumption of dry legumes concerning the global nutrient deficiencies plays a key role in the farming structure of developing countries. To solve the global food shortage problem and improve the consumption of legume grains, recent technologies can be adapted by means of research projects focusing on the fortification of legume grains, which may also help in meeting the expectations rapidly. Some legumes that contain major and minor components such as proteins, fats, carbohydrates, calcium, iron, sodium, vitamin E and riboflavin, can be utilized for chocolate production along with other ingredients like cocoa powder, sugar and butter. In an endeavor to increase the natural flavor in chocolates, fruit peels are added in the powder form. Fruit peels are waste materials produced from fruits processing and juice extraction industries and contain natural products such as antioxidants, antimicrobials, colorants, and phenolic compounds [26],[27]. Fruit peels are easily available by-products. Citrus peel is good source of polyphenols for value-added products and for designing new food products [28]. The large amount of nutrients present in the citrus peel can be used in the preparation of chocolate. Furthermore citrus peel enhances the nutritional value of the chocolate, and is cost effective [29].The rheological behavior and flavor of chocolate influenced by the addition of cocoa butter and citrus peel powder can increase the quality of milk chocolate [30]. Objective of this study was to produce and obtain the sensory profile and acceptability of legumes based milk chocolates produced from different legumes. The effects of substituting the standard cow milk with legumes milk on the physico-chemical properties of the chocolates were also evaluated.

2. MATERIALS AND METHODS

2.1 Raw materials

Soybean (*Glycine max*), yellow pea (*Pisum sativum*), peanut (*Arachis hypogaea*), butter, cocoa powder, jaggery and milk powder were purchased from the local super market in Chidambaram, Tamil Nadu, India. Extensive care was taken during screening to ensure the quality of raw materials and mold-free legumes. Citrus peel was dried in a tray drier at 60-65˚C for 24 h to improve the shelf life of citrus by-products without addition of any chemical preservative. A grinder mill and a sieve were used to obtain the citrus powder with a particle size of <0.2 mm.

2.2 Sample pre-treatment

Weighed quantities of beans and nuts were blanched by submerging in boiling water for 1 and 5 min respectively as shown in Fig.1 & 2, drained and dehulled. The dehulled beans and nuts were soaked in 2% $NaHCO_3$ for 3 and 18 h respectively, and washed in clean water, to remove the bean flavor in the final product and soften the peanuts [18].

2.3 Extraction of legumes milk

The soaked beans and nuts were grounded separately using a blender in the ratio of 2:1 (Legumes:Water). Blending was performed to obtain a smooth, fine, homogenized liquid, which was filtered using a muslin cloth to obtain legumes milk as shown in Fig.3. The homogenized milk from beans and nuts were pasteurized at 80^{o}C for 15 min, and then cooled to room temperature for future use.

Figure: 1 Soaked peanuts and soybean Figure: 2 Soaked yellow peas and peanuts

2.4 Preparation of chocolates

Legumes-milk in definite proportions was heated below its boiling point, and then specific quantities of cocoa powder, butter and jaggery were added with continuous string to obtain a fine paste. The paste was poured in a mold, kept in refrigerator to obtain a desired shape. Chocolates were prepared using different ratios of PN:SB and PN:YP as desired and it is shown in Fig.4. Control milk chocolate was prepared with cows' milk following the same procedure. Physico-chemical properties of the chocolates such as total carbohydrates, fats, proteins, minerals (Na, Li, K and Ca), vitamin C, folic acid, moisture, ash and pH were analysed.

Figure: 3 Extracted milk from soyabean,peanut and yellow pea

2.5 Experimental design

PN:SB and PN:YP at ratios of 1:1, 1:2, 1:3 and 1:4 were used for making chocolates with all other parameters kept constant, and cows' milk chocolate as control, in total nine sets of chocolates were prepared. All the experiments were carried out in triplicate, and their mean values are presented.

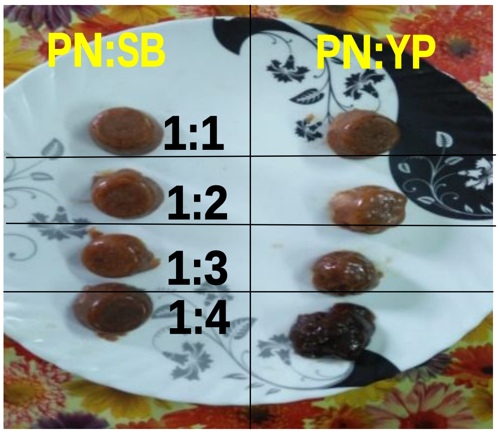

Figure: 4 Legume milk chocolate of PN:SB and PN:YP at ratios of 1:1, 1:2, 1:3 and 1:4

2.6 Chemical analysis

The proximate composition of chocolates was determined in the food processing laboratory using standard methods. Total carbohydrate, protein and minerals (Na, Ca and K) were analyzed using the DNS method, Lowry's method and Flame Photometry, respectively. Folic acid and vitamin C were analyzed using High Performance Liquid Chromatography. Fats were analysed using the Soxhlet method.

2.7 Sensory evaluation for acceptable legumes milk chocolates

Sensory attributes such as flavor, texture, taste, appearance and colour were evaluated using a 9 point hedonic scale (where 9-- like extremely, 8--like very much, 7-- like moderately, 6-- like slightly, 5-- either like nor dislike , 4-- dislike slightly, 3-- dislike moderately, 2--dislike very much, 1-- dislike extremely) by 15 members [31].

3. RESULTS AND DISCUSSION

The present study was carried out to standardize the process for production of legumes-milk chocolate using peanut milk, soy-bean milk and yellow-pea milk; formulations for the production of legumes-milk chocolates were selected on the basis of their sensory and nutritional properties.

3.1 Physical and Chemical Characteristics of legumes-milk

The physico-chemical characteristics of legumes-milk were determined and considered for chocolate preparations. Among the plant based milks, peanut milk had higher moisture (88.2%) than other milks, and soy-bean milk had higher protein and folic acid content of 4.53g and 16.23g respectively. The physico-chemical characteristics of legumes-milk are shown in Table 1. Legumes-milk has the same constituents of mineral content whereas the carbohydrate is higher in peanut and yellow-pea. Peanuts soaked in $NaHCO_3$ provided a light colored milk and enhanced homogenization [32].Jaggery contains higher carbohydrates of 78%. The nutritional characteristics of legumes- milk are comparable to those of cows' milk but the viscosity of milk slightly varies. The beany flavor of legumes-milk is the main characteristic responsible for the low acceptability of legumes based milk chocolates.

Table 1: Physical and chemical characteristics of legumes-milk and cow's milk

Milk Types (per 100 ml)	Moisture content (%)	Total solids (%)	pH	Acidity (%)	Protein (g)	Carbo hydrates (g)	Fats (g)	Mineral (g)	Ash (%)
Cow's milk	86.50	13.50	6.6	0.16	3.3	4.4	3.5	0.7	0.73
Soy-bean milk	90.2	8-10	6.7	0.63	4.8	2.0	2.6	0.56	0.4
Peanut milk	90.40	11.78	6.7	0.34	2.46	2.0	4.4	0.5	0.11
Yellow-pea milk	88.58	9.6	6.5	0.26	3.03	2.12	2.34	0.56	0.5

3.2 Physico-chemical analysis of legumes-milk chocolates

The physico-chemical properties of legumes-milk chocolates prepared using different ratios of legumes and those of control milk chocolate (CMC), dairy milk chocolate (DMC) and milky bar chocolate (MBC) were analyzed. Carbohydrates supply the energy for the body's automatic activity in our daily tasks and are important in nutritional labelling. The carbohydrate content in legumes-milk chocolate and in control chocolates are shown in Table 2. The total sugar content was calculated by the DNS method, which includes glucose, fructose and sucrose. The highest total sugar content of 42,8g was found in 1:1 ratio of peanut:yellow pea milk chocolate, whereas the lowest of 45 g was found in 1:2 ratio of peanut:soybean milk chocolate.

Table 2: Carbohydrates content of legumes-milks chocolates and reference chocolate

Carbohydrates	Peanut:Yellow pea				Peanut:Soybean				CMC	DMC	MBC
	1:1	1:2	1:3	1:4	1:1	1:2	1:3	1:4			

Glucose	11.4	8.4	8.6	8.6	14.2	11.2	9.0	7.0	9.2	7.8	7.0
Fructose	7.4	7.0	6.4	5.4	9.0	10.8	6.4	8.2	11.4	7.8	9.2
Sucrose	24.0	22.8	20.2	20.4	17.6	23.0	21.6	24.0	24.0	20.8	7.8
Total Sugar	42.8	38.2	37.2	34.4	40.8	45.0	37.0	39.0	44.6	36.4	24

CMC - Control Milk Chocolate, DMC - Dairy Milk Chocolate, MBC - Milky Bar Chocolate

The control milk chocolate had 44.6 g of total sugar content. The total sugar content in control milk chocolates ranged from 37.0 to 45.0 g which was lower than that in the soy-bean milk chocolate and skimmed milk powder chocolates, and this may be due to the addition of jaggery.

During processing, the flow characteristics influence the flavor and shell life of chocolates by its moisture content. A tiny drop of water can convert the melting chocolate into a grainy or even-sized, solid mass. The data show that the moisture contents of legumes-milk chocolate and the control were 0.61 ± 1% to 0.50 ± 1%, respectively. The moisture content in legumes-milk chocolate was lower than that of soy-bean milk chocolate [18] and close to that of skimmed milk powder chocolate [1]. The low level of moisture content in legumes- milk chocolate is due to the addition of jaggery instead of sugar.

The ash content in legumes-milk chocolates for various ratios was similar; it characterizes the total minerals, i.e., the inorganic residues after the complete oxidation of organic matter in a food product. The ash content in legumes based milk chocolates was higher than that of soy-bean milk chocolate reported in the literature [18] and close to that of skimmed milk powder chocolate [1]. Variation in the nutritional composition of chocolates between the literature and our experiment was due to the difference in the water content, and the selection of soybean and peanuts used in the experiments. Because of the long soaking hours, the minerals might have leached out of the ingredients; it is also reported that soaking beans for 24 hours resulted in a 5% loss of total solids. In legumes-milk chocolates ratio 1:1 showed the close value as the cows' milk chocolates.

The pH values of legumes-milk chocolates and the control milk chocolate were recorded. Among the chocolates prepared at four ratios of PN:YP, the ratio at 1:2 had the highest pH of 5.77, whereas 1:4 had the least pH of 5.35. In PN:SB chocolate, 1:1 ratio had the highest pH of 5.67, whereas 1:3 ratio had the least pH of 5.04. It was observed that acidity decreased with increase in the amount of soybeans and peanuts in the product, but it increased with increase the amount of cocoa powder. All the pH values of legumes-milk chocolates were comparable to those of cows' milk chocolate and chocolates available in the local markets.

Fat particles are suspended in chocolates as continuous phase, and also increase in fat content increases the continuous phase and decreases the viscosity. In any given feed, the main source of energy is fat, thus the most important constituent of a food product is fat. The fat contents of legumes-milk chocolate and those of the control chocolates were calculated and are shown in Table 3. Peanuts are known to contain about 49.24% fat. Therefore, the relatively higher fat content in all the legume-milk chocolates than that in the cows' milk chocolate was due to the addition of peanuts in the formulation. The fat content in the soybean peanut beverage was higher than that of peanut milk reported in a previous study by Gatade et al. (2009). The average fat content in legumes based milk chocolates was 30.4125 ± 0.81%, which was lower than that of imported dark chocolates (37.08 ± 5.05%). Our result was within the range reported by Afoakwa (2012) that is 30 to 40% of fat content [33]. The fat content in legumes-milk chocolate (30±0.9) was less than that of the control milk chocolate prepared with cows' milk (32±3.5).

Table 3: Physico-chemical properties of the various ratios of Peanut milk: Yellow-pea milk chocolate, Peanut milk: Soy-bean milk chocolate, and Control milk chocolate

Parameters	**Peanut milk: Yellow-pea milk chocolate**				**Peanut milk: Soy-bean milk chocolate**				**Control milk Chocolate**
	1:1	**1:2**	**1:3**	**1:4**	**1:1**	**1:2**	**1:3**	**1:4**	
Moisture (%)	0.61	0.61	0.60	0.63	0.65	0.63	0.66	0.64	0.5
Ash (%)	1.73	1.55	1.74	1.51	1.0	1.81	1.76	1.89	1.72
pH	5.45	5.77	5.46	5.35	5.67	5.12	5.04	5.26	5.4
Fat (%)	30.2	30.5	30.1	30.5	30.5	30.7	30.6	30.2	35.8
Carbohydrates (%)	42.8	38.2	37.2	34.4	40.8	45.0	37.0	39.0	44.6

Protein (g/100g)	1.35	1.37	1.41	1.40	1.39	1.42	1.43	1.45	1.06
Sodium (g/100g)	5.2	6.6	6.8	7.4	7.2	6.8	6.4	7.5	4.5
Potassium (g/100g)	9.9	8.4	8.3	7.5	8.6	11.2	8.7	8.6	9.2
Lithium (g/100g)	6.1	6.1	6.0	6.0	6.2	6.1	6.0	6.0	6.0
Calcium (g/100g)	5.5	5.2	5.0	5.0	5.0	5.0	5.0	5.0	5.0

Plant based proteins are better for sweet taste and are important for all biological functions and cell structure. The protein content of various ratios of legumes-milk chocolate ranges from 1.06 to 1.45 g per100g. The lower value was observed in yellow-pea milk chocolate then the soy-bean milk chocolates (1.06 g) and 11.58±0.36 % from skim milk powder chocolates. Proteins could not be extracted thoroughly, because some are not water soluble. Peanuts contain a low protein content, which further decreased in the final mixture composition. Milk contains higher amount of fat, which interferes with the solubility of the proteins and decrease the protein content in chocolates.

Mineral content is a measure of the amount of specific inorganic components present in a product food such as sodium, potassium, lithium and calcium. The mineral content varied significantly among different legumes based milk chocolates. The control milk chocolates had the highest content of potassium and lowest content of sodium among all the milk chocolates. Among the different ratios of legumes-milk chocolates, potassium was higher in PN:SB chocolates than that in PN:YP milk chocolates. The mineral contents of soy-bean and yellow-pea milk chocolates were higher. The findings in terms of mineral content in the present study of legumes-milk chocolates are comparable with those reported in the literature and also with various control chocolates. The Vitamin C content ranged from 0.326 to 0.456 g for legumes-milk chocolates whereas it was 0.263 g in cows' milk chocolates. The increase in ratios for both legumes-milk PN:YP and PN: SB shows the increase in vitamin C content.

3.3 Sensory analysis

Sensory profile is the most important characteristic that contributes to the overall quality of a product. It is the property by which the consumer first identifies and associates his likeability to a particular product. The sensory evaluation for the four ratios 1:1, 1:2, 1:3 and 1:4 of PN:YP milk chocolate and PN:SB milk chocolate was carried out on the basis of color, flavor, taste, texture and overall acceptability. The sensory evaluation was carried out in triplicate using 9-point hedonic scale by a panel of 20 members. All the legumes-milk chocolates were compared with the cows' milk (control). Among the four ratios, in terms of overall acceptability, the 1:1 ratio of PN:YP milk chocolate scored 8.45, and 1:2 ratio of PN:SB milk chocolate scored 7.75. In terms of all sensory parameters, 1:1 ratio of the PN:YP and 1:2 ratio of the PN:SB chocolate were the mostly accepted ones by the panel. The better mouth feel may be attributed to the higher fat content of the samples, and fat is known to be associated with good mouth feel.

Table 4: Sensory analysis for the various ratios of Peanut milk: Yellow-pea milk chocolate, Peanut milk: Soy-bean milk chocolate, and Control milk chocolate

Parameters	Ratios	Colour	Flavour	Taste	Texture	Overall Acceptability
Peanut milk: Yellow-pea milk chocolate	1:1	7.65	8.15	8.4	8.05	8.45
	1:2	7.7	7.8	7.55	7.55	7.75
	1:3	7.05	7.15	7.5	7.3	7.45
	1:4	6.85	6.7	6.7	6.95	6.95
Peanut milk: Soy-bean milk chocolate	1:1	7.5	6.85	7.3	7.05	7.55
	1:2	7.9	7.45	7.25	7.6	7.75
	1:3	7.55	6.95	7.0	6.75	7.35
	1:4	6.35	6.7	6.5	6.6	6.95
Control milk chocolate	-	7.69	7.2	7.89	7.65	7.9

3.3.1 Sensory analysis of Peanut and Yellow-pea (PN:YP) formulation of chocolates

The acceptance of the chocolate was evaluated on the basis of color, flavor, taste, texture, and overall acceptability; and the results of 1:1, 1:2, 1:3 and 1:4 formulations are shown in Table 4. Among the different ratios of PN:YP analyzed for nutritive value, it is evident that the nutritive value was highest for combination 1:1 owing to the least amount of dilution involved in the formulation. Although sensory analysis of this combination revealed that the composition of the PN:YP milk chocolate was quite closer to the dairy milk chocolate reported by Manpreet Singh et al., (2017). Table 4 also shows the average score of the following sensory attributes. 1:1formulation scored high and was considered the best among all the formulations. In the ratios 1:1 had better flavor, taste, texture and overall acceptability, whereas 1:3 and 1:4 formulations had high beany flavour. On the basis of sensory characteristics, 1:1 formulation of PN:YP milk chocolate had good flavor due to the addition of citrus peel powder with high overall acceptability as that of the commercial chocolate available in the market.

3.3.2 Sensory analysis of Peanut and Soy-bean (PN:SB) formulation of chocolates

The evaluation of adequacy of different formulations of soy-bean milk with Peanut milk was carried out on the basis of nutritional attributes and sensory profile. Ash, fat and protein contents in 1:2 formulation ofPN:SBmilk chocolates were 1.81%, 30.7%, 1.42 g, respectively, which were significantly higher than those in 1:1, 1:3 and 1:4 formulations. Ash, fat and protein contents for PN:SB 1:1, 1:3 and 1:4 formulations were 1.00%, 30.5% and 1.30g; 1.76%, 30.6% and 1.43g; and 1.89%, 30.2% and 1.45g, respectively. The nutritional value was found to be highest for 1:2 formulation, because of being the optimum diluted formulation.

The composition of PN:SB milk chocolate was quite closer to the dairy milk chocolate reported by Manpreet Singh et al., (2017). Table 4 shows the average score of the sensory attributes of PN:SB milk chocolate. 1:2 formulation scored high and was considered the best among all the formulation. In the 1:1 formulation, the color, taste, texture and overall acceptability were good, but the flavor was not acceptable due to slight beany flavor. The addition of citrus peel powder provided a pleasant aroma along with the beany flavor in the 1:2 formulation. The 1:2 formulation of the PN:SB milk chocolate had good flavor with high overall acceptability and also displayed a better mouth feel than the other three formulations.

3.3.3 Performance evaluation of legumes-milk chocolates using radar chart

The performance of primed legumes-milk chocolates were evaluated using sensory analysis and the average scores of each attributes are represented in the radar charts for each sense. Among the two sets of legumes-milk chocolates, the 1:2 formulation of PN:SB milk chocolate had the highest mean value in color (7.5), flavor (7.45), texture (7.6) and overall acceptability (7.75) with the second highest mean value in taste (7.25) as shown in Figure 1; and the 1:1 formulation of PN:YP milk chocolate had the highest mean value in flavor (8.15), taste (8.4), texture (8.05) and overall acceptability (8.45) with the second highest mean value in color (7.7) as shown in Figure 2.

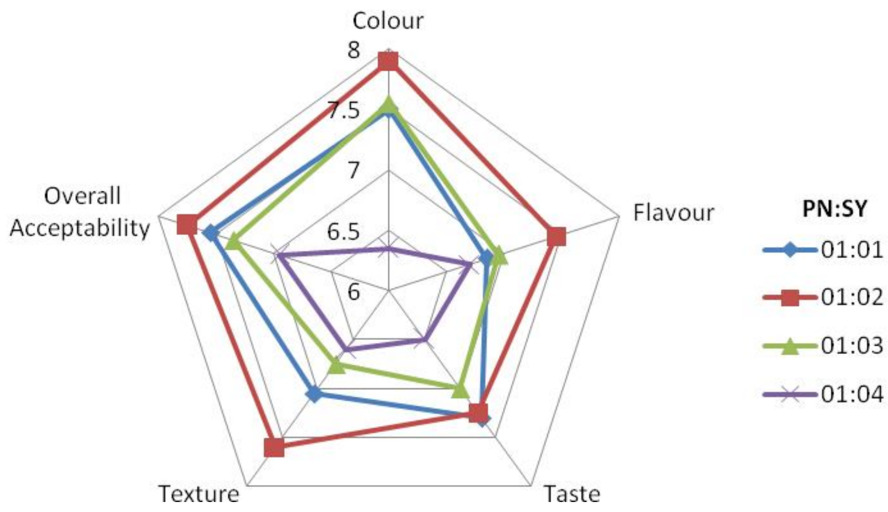

Figure 1: Representation of the sensory analysis of Pea-Nut milk: Soy-Bean milk chocolates

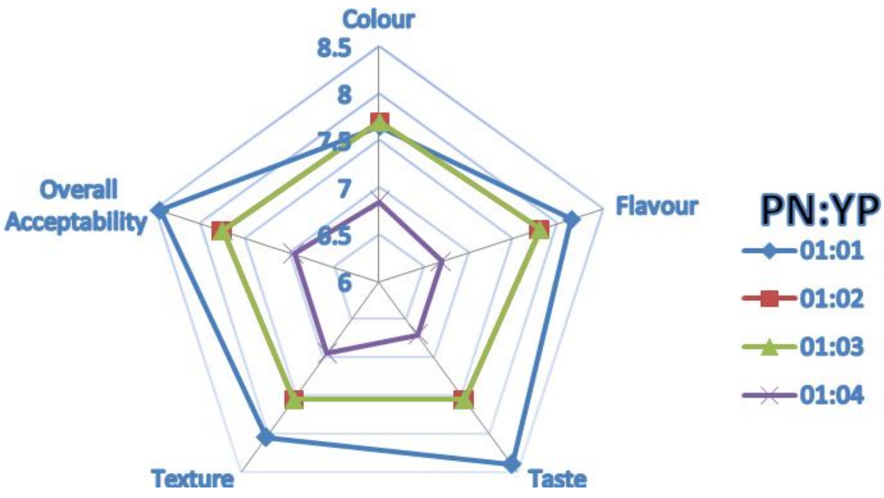

Figure 2: Representation of the sensory analysis of Pea-Nut milk: Yellow-Pea milk chocolates

4. CONCLUSION

Among all the confectionary products, chocolate are highly preferred for consumption; however, cows' milk used in the dairy chocolates have some limitations. To overcome the limitations a good substitute for cows' milk is highly preferred and legumes based milk is a good alternate because they are highly nutritive, feasible, and low cost [34]. In this work, two legumes-milks (Soy-Bean milk and Yellow-Pea milk) were taken in combination with peanut milk at four different formulations 1:1, 1:2, 1:3 and 1:4 to prepare chocolates. Sensory evaluation and proximate analysis of the milk chocolate were carried out. Among the formulations,1:2 ratio of Pea-Nut milk: Soy-Bean milk, and 1:1 ratio of Pea-Nut milk: Yellow-Pea milk chocolates were of good quality in terms of flavor, taste, texture, color and overall acceptability; which were comparable to those of existing chocolates, and may be due to the aroma of citrus peel powder in legumes-milk chocolates.

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