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Application of Principal Component Analysis as Properties and Sensory Assessment Tool for Legume Milk Chocolates

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Abstract

Principal component analysis (PCA) was employed to examine the effect of nutritional and bioactive compounds of legume milk chocolate as well as the sensory to document the extend of variations and their significance with plant sources. PCA identified eight significant principle components, that reduce the size of the variables into one principal component in physiochemical analysis interpreting 73.5% of the total variability with/and 78.6% of total variability explained in sensory evaluation. Score plot indicates that Double Bean milk chocolate in-corporated with MOL and CML in nutritional profile have high positive correlations. In nutritional evaluation, carbohydrates and fat content shows negative/minimal correlations whereas no negative correlations were found in sensory evaluation which implies every sensorial variable had high correlation with each other.

Keywords

Principal Component Analysis, Legume Milk Chocolate, Bioactive Plant Source, Nutritional and Sensory Properties

1. Introduction

In recent days, curiosity in diet has increased the consumers' attention towards the healthy foods such as legumes, pulses and nuts [1]. It is acknowledged as a preeminent thing, not only for nutrition, but also for preventing and treating the diseases owing to the inadequate and unbalanced nutritional consumption [2]. This leads to the demand for health-giving food commodities with improved dietary characteristics including unique constituents for the avoidance of health issues. The arising of an innovative supplementary probability for products with health benefits and furthermore elementary nourishment, which meets the consumer expectancies and also it concurrently strengthens the development of functional foods which has been syndicated with the numerous components like bioactive compounds obtained from plants, polyunsaturated fatty acids, probiotics, prebiotics, minerals and vitamins [3].

Currently, consumers have inclined towards the plant-based diet which consists of cereal, legumes, seeds, nuts, fruits, and vegetables and also for various reasons which include a strong aversion to animal ruthlessness, a craving for a healthy standard of living and the healthy consciousness of our environment. A wide variety of tendencies like veganism, vegetarianism, lacto-vegetarianism, and ovo-vegetarianism have come birth. Veganism which defines us as not consuming any kind of meats, sea foods, milk or dairy products, eggs, honey or other products that contains any amount of these foods. Plant-based milk alternatives are one of the food groups that anyone cannot deny in the vegan food industry [4], because plant-based milk replacements play a vital role in lots of vegan food products such as plant-based yogurt, cheese, kefir, butter and ice cream, etc. In addition to that, plant-based milk substitutes are greatly needed for those who are having an intolerance to lactose or someone allergic to cow's milk [5]. Hence nowadays the formulation of chocolate with plant-based milk has increased greatly. Gatade *et al.* 2009 have prepared the soymilk chocolate as nutritionally equivalent to milk chocolate [6]. Plant-based milk substitutes have significant benefits such as rich source of antioxidants [4] [7] [8] and fatty acids which can even reduce the risk of heart disease, cancer, atherosclerosis, and diabetes [9] [10].

Legume-based beverages compromise several nutritional benefits over dairy products with isoflavones, phytosterols, polyphenols and prebiotic oligosaccharides. They are inexpensive, refreshing and nutritional beverage with different functionally active component responsible for their beneficial interactions inside the body [11]. The plant-based milk substitute begins with the Soybean formerly in China before 2000 years which was the most prominent beverage that provides nutrients in the scarce inhabitants followed by Peanut. Peanut is the second most non-dairy beverages which partake the important consumption in the low-income groups, malnourished children, vegans, and populations having cow's milk allergy thereby increasing the development of the world [12] [13].

Furthermore the reviews for the underutilized legumes have increased for the other alternative protein source to fulfill the essential requirement of the vegetal proteins. Other than soy, the underutilized legumes have significant possibilities for food security, satisfying the nutritional demand also for the growth of agronomic. Various well-known underutilized legumes including Lima (Double) bean, Kidney bean, cowpea and chickpea comprises of sufficient quantities of protein, essential amino acids, minerals and vitamins, dietary fiber, polyunsaturated fatty acids along with advantageous bioactive compounds [14]. Gamli & Atasoy (2018) has suggested the creation of yoghurt by the peanut milk with taste and flavour enhancement utilized for future use [15]. Formulation of dehydrated peanut-cowpea milk chocolate with 22.3% cocoa butter and 30% sugar shows the highly acceptable chocolate based on the sensory attributes and helps in lower the chocolate costs [16] [17]. In recent days, focusing on plant study has increased because of its medicinal, therapeutic and pharmacological properties owing to treat the proliferating rate of metabolic disorders in mankind. India follows conventional usage of several herbal sources for Ayurveda, Unani, Siddha, Homoeopathy and Allopathy also as spices, home-remedies, health foods including as self-medication and drugs. Compounds present in Citron medica leaf aids to act as antioxidant, anti-inflammatory, estrogenic activity, antiulcer activity, antidiabetic activity, antihypertensive effect, antithyroid activity, antihyperglycemic activity, antianxiety effect, anticancer activity with various health benefits [18]. Moringa Oleifera leaves has good strategy of numerous functional components and nutrients including vitamins, Minerals, etc. henceforth it aids to treat several chronic diseases, including hypercholesterolemia, high blood pressure, diabetes, insulin resistance, non-alcoholic liver disease, cancer, overall inflammation, heart disease, diabetes, cancer and fatty liver [19]. Besides it is emerging towards as the value-added ingredient for both bakery and meat products [20] [21]. The flowers of Senna auriculata (Avartaki) is well known to have antidiabetic, antioxidant, antihyperlipidemic, hepatoprotective, antipyretic, antimicrobial activity. It helps to cure disorders related to urinary system and eye [22]. Numerous dimensional data sets are challenging and hard to predict and elucidate. On the other hand, without exhibiting every data correlated to a interpret of the original progression, a reduced intrinsic dimensionality for data set generally occurs. Effort for necessity of techniques has arised to reduce the dimensionality of the data sets with maximal information exist in the original data, concurrently with insignificant error between the original data and the newly reduced dimensional illustration along with analysis of correlations between the variables. To fulfill this requirement, PCA is one among the most popular conventional dimensionality reduction analysis in which the conversion of information between the original and the newly reduced dimensional data were represented in a linear projection [23].

PCA was initiated by Pearson in 1901 to determine lines and planes for fitting set of points in the p-dimensional space. Later PCA was evolved with algebraic form by Hotelling in 1933 analogues to the Factor Analysis. PCA substantial affords three outputs namely variance, loadings and scores. With the original data matrix PCA model can be generated by various techniques such as the Power method, Singular Value Decomposition (SVD), Nonlinear Iterative Partial Least Squares (NIPALS), etc. The data points were disseminated in the k-dimensional space where the factor defines the data set which is known as variance. The variance described principles that originates (with 90% or 95%) to cumulative variance. The Cattell's scree plot was introduced by Raymond B. Cattell in 1966 is a line plot represents the described variance against the PCs or the eigenvalues of the factor. The layout of the plot appears in declined mode the cut-off is instructed prepared the elbow of the diagram, where the steep part of the figure straightens. The Kaiser's criterion is a dominant and advantageous factor retention method, that reduces PCs with the eigenvalue lower than 1. Loading Plot represents the correlation between the newly created PCs and the original data by loadings values. Analytically, loadings explain the prediction of initial space in the direction of the maximum variance. Score Plot describes at the time of creating PCA model with original data, k dimensional space is given by definite number of PCs on selection. The scores are the correlation of the primordial information in the freshly created low dimensional space [24].

2. Materials and Methods

2.1. Procurement of Ingredients

Legumes-Peanut, Double Bean, Red Kidney Bean, Yellow Pea and Chick Pea, Cocoa Powder, Butter, Jaggery used in the study were procured from the local market in Chidambaram, Tamilnadu, India as shown in **Figure 1**. Fresh Leaves of Citron (Citron medica) and drumstick (Moringa olifera) and Flower of Tanner's Cassia (Senna auriculata) are obtained from local place as shown in **Figure 2**.

2.2. Legumes Pretreatment and Extraction of Legumes Milk

Extensive care was taken during screening, to ensure the quality of raw materials and mold free legumes. Blanching was done to decrease the surface microbes and to inactivate the enzymes which is responsible for the beany flavor at 60˚C, less than 2 minutes. The dehulled peas and nuts were soaked in 2% $NaHCO_3$ for 3 h and 18 h respectively, and washed thoroughly in clean water to soften and ensure the removal of beany flavor in the final product [25]. Soaked peas and nuts were grounded separately using blender in the ratio of 2:1 (Legumes: Water). It was blended to obtain a smooth, fine, homogenized liquid, and then filtered with muslin cloth to obtain legumes-milk. The homogenized milk from peas and nuts was pasteurized at 80˚C for 15 minutes and then cooled to room temperature for future use.

2.3. Preparation of Plant Sources

Plant materials were collected and shade dried to maintain aroma and color. Plant material is dried till attaining <5% of moisture. Dried plant materials are blended to obtain fine powder with mesh size of less than 2 μm. Powder was stored in air tight container for future use.

2.4. Formulation of Legumes-Milk Chocolate

Functional legumes-Milk Chocolate was prepared in laboratory level by maintaining less than 45˚C with added definite proportions of the ingredients. The obtained chocolate paste was tempered and poured in molds and refrigerator at 4˚C for 2 h. The experiment was carried out for all sets of chocolate. The chocolate bar was wrapped with aluminium foil and stored under refrigerated condition.

Figure 1. Ingredients.

Figure 2. Plant sources.

2.5. Preparation of Chocolate Extracts

All chocolate samples were granulated till attaining fine powder with mortar and pestle. Lipid elimination was not carried out due to study the quantification of fat in chocolate. 1 g of sample was homogenized with water to obtain 10-1 dilution. The sample was kept in shaker for 2 - 3 h. The diluted sample was centrifuged at 1500 rpm for 15 mins. The supernatant was collected and used for all analyses. Analyses were done in triplicate.

2.6. Quantification of Nutritional Properties

The proximate analysis of legumes-Milk chocolates was determined by AOAC standard method. Protein content was estimated quantitatively by Lowry's method with Bovine serum albumin as standard, Carbohydrates by 3,5-dinitrosalicylic acid (DNS) Method with glucose as standard, Total Phenolic Content was by Folin-Ciocalteu with Gallic acid as the standard, Total flavonoids content by Aluminium chloride with Quercetin as standard, Antioxidant with Trolox as standard using spectrophotometer. Fat content was determined by Soxhlet method. Vitamin C and Folic Acid by HPLC was determined by High Performance Liquid Chromatography (HPLC SPD 20A C18) with C18 Column, Flow rate: 0.5 ml/min, UV wavelength: 210 nm, Mobile phase: Acetonitrile/H_2O (70:30), Detector: UV detector, Pump A: 135 KgF/cm^2, Pump B: 135 KgF/cm^2, Injection Volume: 20 µl.

2.7. Sensory Properties and Data Analysis

Sensory Analysis is important for the acceptability of the food product to commercialize. The experimental samples were subjected to sensory evaluation after one week. Sensory panel consist of 20 non-expert members and chocolate sample was evaluated for 8 different sensory attributes namely Taste, Texture, Color, Aroma, Mouth feel, Flavor, Appearance and Overall Acceptability using 9-point hedonic scale where 9-Like Extremely, 8-Like Very Much, 7-Like Moderately, 6-Like Slightly, 5-Neither Like nor Dislike, 4-Dislike Slightly, 3-Dislike Moderately, 2-Dislike Very Much, 1-Dislike Extremely). Sensory Evaluation was performed in triplicated for each sample.

Dataset is obtained which consists of 20 samples and 8 variables for nutritional properties and sensorial characteristics. PCA was applied to analysis the data by studying the correlations between the responses among the sensorial attributes where the variables are Protein, Vitamin C, Carbohydrates, Fat, Folic Acid, TPC, TFC and Antioxidant Activity-DPPH IC50 and also among the Sensory attributes where the variables are Taste, Texture, Color, Aroma, Mouth feel, Flavor, Appearance and Overall Acceptability. PCA was done using Minitab software (Minitab version 17). Correlation coefficients and regression coefficients were obtained among the nutritional properties and among the sensory characteristics of Legume Milk Chocolate. Correlation coefficients were applied to form the matrix and extract the Eigenvalue.

2.8. Principal Component Analysis

PCA is statistical tool employed to evaluate multifarious data precisely and it reduces the complexity of the variables into simpler form by convert the data matrix to a fractional amount of variables also elucidating correlation among the multiple variable. The main intention is data compression and examining the number of components that are required for describing the superior part of variance with less information loss [25]. It was applied to study the correlation of nutritional parameters and among the sensory characteristics of before and after addition of plant source in legumes-milk chocolate. Multivariate Data were evaluated by a PCA where the variables for the nutritional parameters are protein, Vitamin C, Carbohydrates, Fat, folic acid, TFC and AA-DPPH and for sensory evaluation the attributes were Taste, Texture, Color, Aroma, Mouth feel, Flavor, Appearance and Overall Acceptability. Considering the variability of the dimensions of the responses, correlation coefficients were applied to form the matrix and extract the Eigenvalue.

3. Results and Discussion

3.1. Nutritional and Phytochemical Properties of Legume Seeds, Milk and Chocolate

The nutritional properties and bioactive components of seed, milk and chocolates of various legumes such as Peanut (PN), Double bean (DB), Red kidney bean (RKB), Yellow pea (YP) and Chick pea (CP) are represented in **Figure 2** & **Figure 3**. The nutritional properties such as Protein, Vitamin C, Carbohydrates, Fat and Folic acid were represented in **Figure 3**. The bioactive components such as TPC, TFC and Antioxidant Activity, DPPH are shown in **Figure 4**. It shows an increase in the nutritional level of the Legumes-Milk Chocolate then the seeds and milk of various legumes. The amount of protein present in PN, DB, RKB, YP and CP based chocolates are 2.93, 2.49, 2.603, 2.115 and 2.353g respectively.

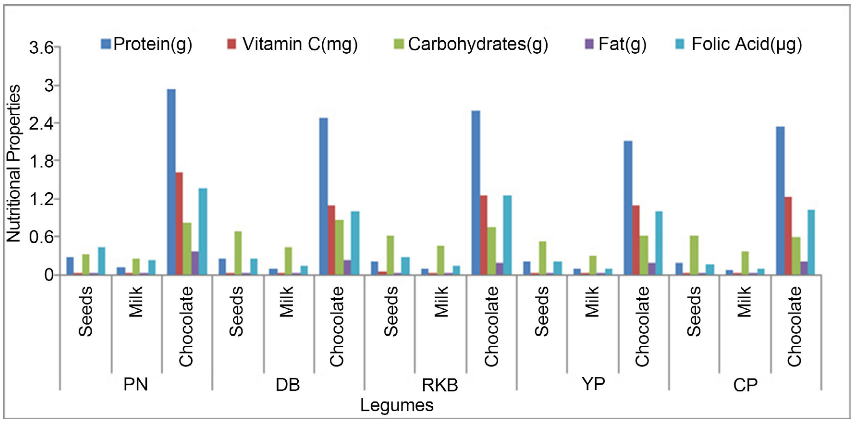


Figure 3. Nutritional properties of legumes milk chocolate.

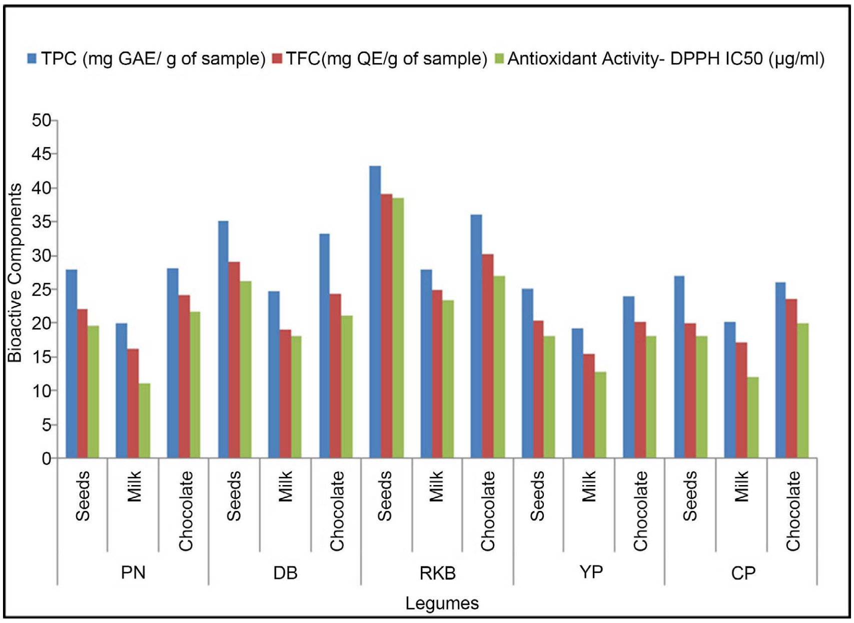
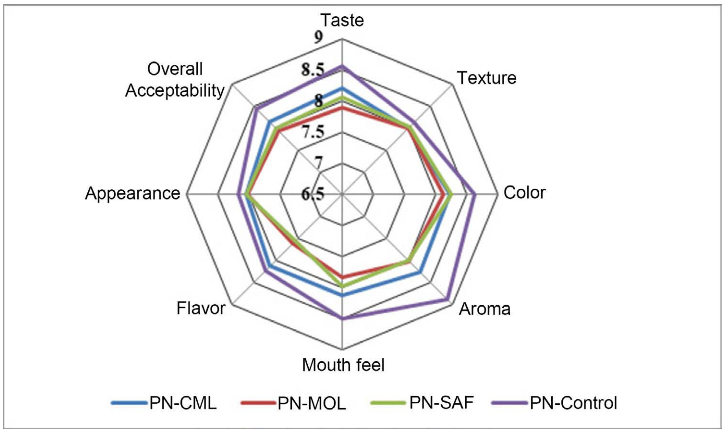


Figure 4. Bioactive components of legumes milk chocolate.

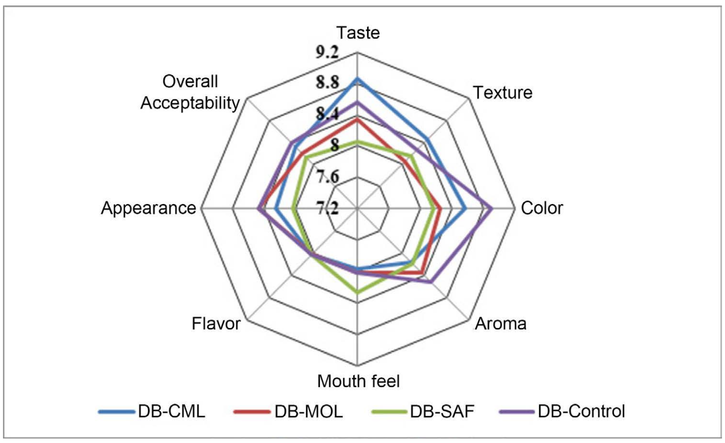
The amount of protein present in peanut based milk chocolate is higher than the red kidney bean based chocolate and also other.

3.2. Sensory Analysis of Legumes Milk Chocolate with Plant Source

Figure 3 represents the spider chart of Legumes-Milk Chocolate with plant source. As shown in Figure 3, the following hedonic scales were used to rank the intensity of these 8 attributes: 9-Like Extremely, 8-Like Very Much, 7-Like Moderately, 6-Like Slightly, 5-Neither Like nor Dislike, 4-Dislike Slightly, 3-Dislike Moderately, 2-Dislike Very Much, 1-Dislike Extremely. The sensory quality of Peanut Milk chocolate (as control) has high aroma, colour, taste and mouthfeel then the CML added chocolate was shown in Figure 5(a). MOL added chocolate shows least sensorial characters. In double bean milk chocolate, CML added chocolates have a sensory profile next to control with good level of colour and aroma as the control chocolate. SAF added chocolate shows less acceptability then the other. Least acceptability of MOL added chocolate in RKB, YP and CP are represented in Figure 5(c), Figure 5(d) & Figure 5(e) whereas CML has good sensorial profile with high level of color. On whole, CML added Legumes-Milk chocolate shows high sensorial profile with high level of sensory attributes whereas MOL and SAF added Legumes-Milk chocolate has the least and moderate acceptability rate, respectively.



(a)



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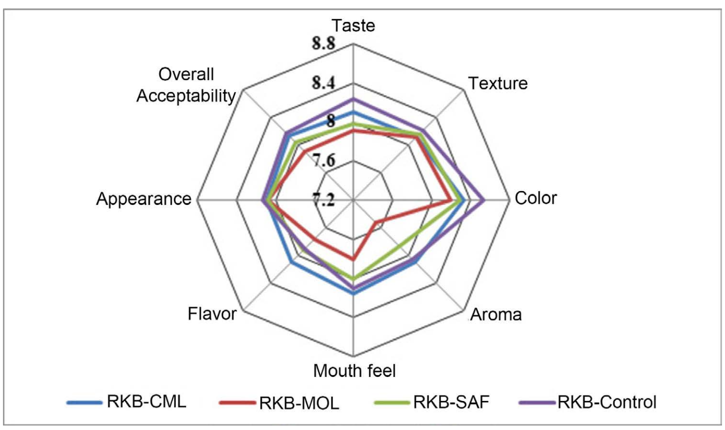
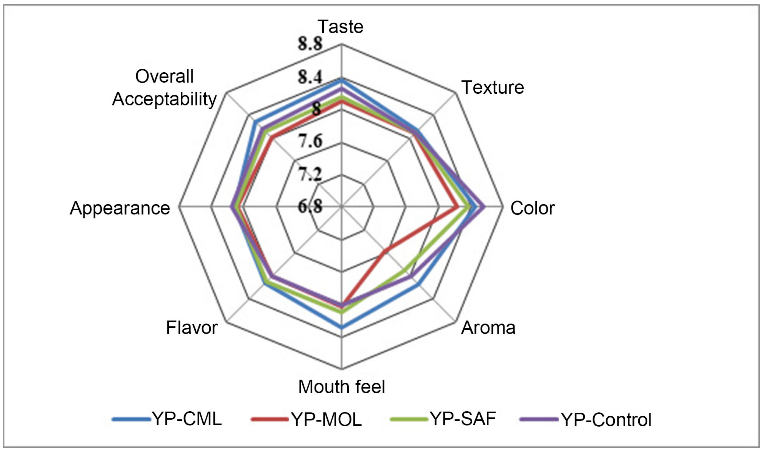


(c)



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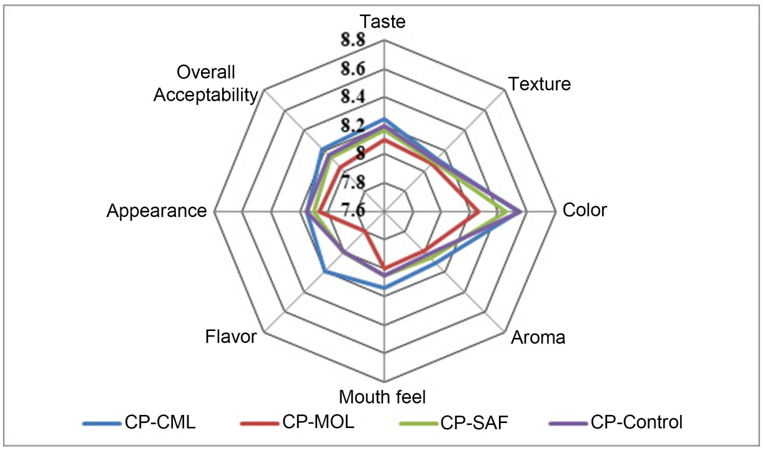

(e)

Figure 5. Spider chart representing Legumes-Milk Chocolate with plant source (a) PN: Peanut; (b) DB: Double Bean; (c) RKB: Red Kidney Bean; (d) YP: Yellow Pea; (e) CP: Chick Pea (CML: Citron medica leaf, MOL: Moringa olifera leaf and SAF: Senna auriculata flower).

3.3. Principal Component Analysis (PCA) for Nutritional and Phytochemical Properties

PCA is one of the most extensively used data mining techniques applied for multitude numerical data. The multivariate data analysis is applied or used only when the data consists of the significant number of correlated variables in which various algorithms and techniques were used to analyze and interpret the datasets. In this method, the responses are analyzed as a result of the exerted treatments on the samples in the vector space based on the correlation between the extracted data in a dataset [26]. This paper aims to give an outline study on application of principal component analysis in the nutritional and the sensory properties of Legume-Based milk chocolate to define and evaluate the correlations among the studied responses. Considering the variability of the dimensions of the responses, correlation coefficients were applied to form the matrix and extract the eigenvalue.

The PCA is a multivariate technique of extracting biomolecules from a correlation matrix. Data on nutritional and phytochemical properties were subjected PCA are explained on the basis of Eigenvalues, Proportion and Cumulative of the Correlation Matrix for the eight components. The first two principal components were taken to represent the interactions based on the Kaiser criterion stating eigenvalues greater than 1 [27]. Among the data on eight principal components, second component explains 85.9% variation in the cumulative proportion. The model has taken two principal components (PC1 and PC2), giving eigenvalues more than 1.0 (5.8788 and 0.9916, respectively) and explained 85.9% of the total variability. The component 1 (PC1) defined 73.5% of the variability in the attributes, which had positive response for Protein, Vitamin C, Folic Acid, Total Phenolic Content, Total Flavonoids content and Antioxidant Activity-DPPH IC_{50} with less response for Carbohydrates and Fat. The component 2 (PC2), had 12.4% of the variability in the parameters, received the main positive contribution from Protein, Carbohydrates, Fat, Folic Acid, Total Flavonoids content and Antioxidant Activity whereas Vitamin C and Total Phenolic Content are negatively influenced.

From **Table 1**, the first principal component has large positive associations with Protein, Vitamin C, Folic acid, TPC, TFC and Antioxidant Activity-DPPH hence it primarily measures the enrichment of the nutritional properties in Legumes-Milk chocolate with Bioactive rich Plant sources with minimum carbohydrate and fat content because of the presence of citro flavonoids in Citrus medica which has antidiabetic activity [18]. The second component has negligible and least response of Vitamin C and TPC.

The first component accounted for 73.5% and the second component for 12.4%. **Figure 6** represents the score plot of the correlation between the first and second component of the variable. The score plot clearly defines the nutritional characteristics of all control legumes-Milk chocolate were negatively correlated, and also YP-CML has moderate correlation. Significant correlation was found for PN-CML, PN-MOL, PN-SAF, DB-MOL, DB-SAF, RKB-CML, RKB-MOL and RKB-SAF. From the score plot among all correlations, DB-MOL exhibits high nutritional properties. **Figure 7** represents the Loading plot for the first two components. Protein, Vitamin C, Folic acid, TPC, TFC and Antioxidant Activity-DPPH has positive correlation implies the enormous amount of nutritional properties. Identification of points within the reference line 4.856 shows the correlation is significant as in the outlier's plot. Biplot represents both score and loading plot of the Physiochemical parameters of Plant Source added Legumes Milk chocolate (**Figure 8**).

3.4. Principal Component Analysis (PCA) for Sensory Characteristics

Correlation among each sensory variable of legumes milk chocolate was studied by Principal component Analysis.

Table 1. Eigenvectors for the properties of legumes milk chocolate with plant sources.

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Protein (g)	0.355	−0.267	−0.225	0.44	−0.714	−0.208	−0.074	0
Vitamin C (mg)	0.344	−0.281	−0.494	0.38	0.629	0.109	0.061	0.058
Carbohydrates (g)	−0.351	−0.315	−0.466	−0.28	−0.275	0.614	0.132	0.109
Fat (g)	−0.199	−0.83	0.415	−0.032	0.107	−0.225	0.186	−0.032
Folic Acid (μg)	0.358	−0.131	−0.34	−0.74	0.012	−0.427	−0.097	−0.03
TPC (mg GAE/g of sample)	0.398	0.104	0.138	−0.094	−0.083	0.199	0.791	−0.363
TFC (mg QE/g of sample)	0.398	−0.022	0.309	−0.117	−0.035	0.225	0.052	0.823
Antioxidant Activity-DPPH IC_{50} (μg/ml)	0.386	−0.182	0.292	−0.112	0.012	0.495	−0.549	−0.417

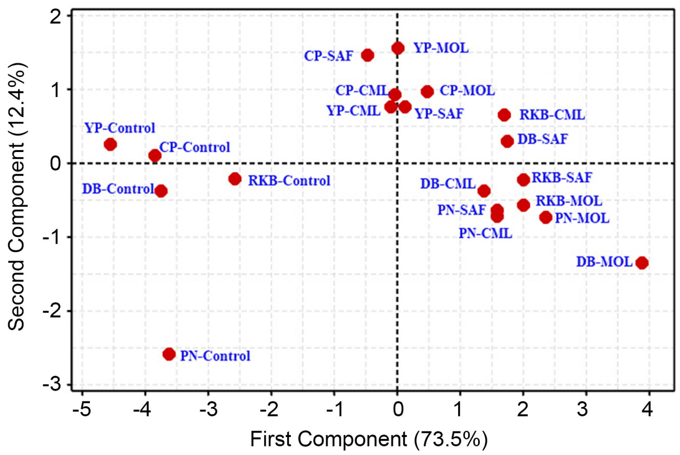

Figure 6. The distribution and correlation represented by Score Plot.

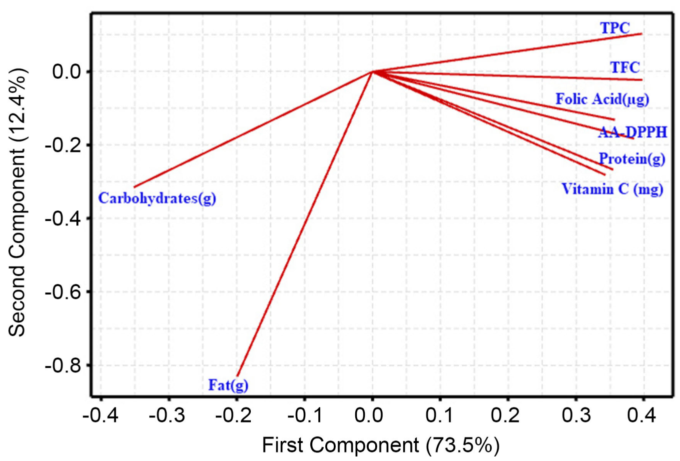

Figure 7. The distribution and correlation between the nutritional and Bioactive properties of Plant Source added Legumes Milk chocolate with control represented by Loading Plot where TPC-Total Phenolic Content (mg GAE/g of sample), TFC: Total Flavonoid Content (mg QE/g of sample) and AA-DPPH: Antioxidant Activity DPPH IC_{50}-(μg/ml).

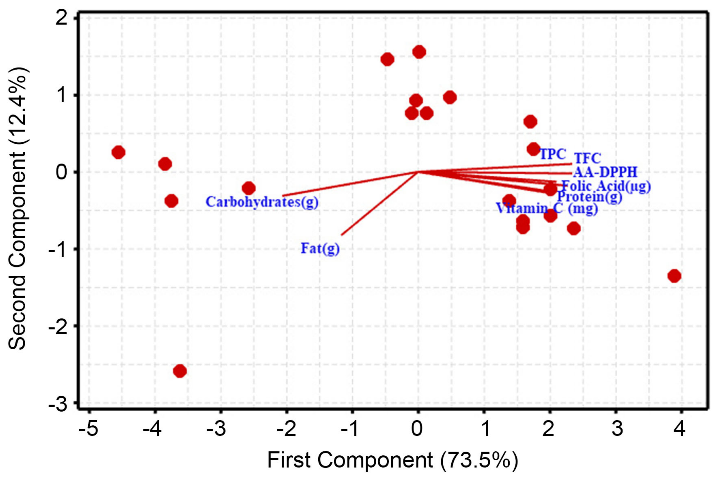

Figure 8. Biplot represents the Physiochemical parameters of Plant Source added Legumes Milk chocolate with control where TPC-Total Phenolic Content (mg GAE/g of sample), TFC: Total Flavonoid Content (mg QE/g of sample) and AA-DPPH: Antioxidant Activity DPPH IC_{50} (µg/ml).

The principal component analysis of sensory properties is explained on the basis of Eigenvalues, Proportion and Cumulative of the Correlation Matrix for the eight components. The first two principal components were taken to represent the interactions based on the Kaiser criterion stating eigenvalues greater than 1. From PCA, we take the first eight principal components, among them the second component explains 78.6% variation in the data obtained from the cumulative proportion. The scree plot orders the eigenvalues from largest to smallest; a steep line followed by a steep curve is obtained after the third component.

From Table 2, the first principal component has positive associations in all variables hence it primarily measures the enhancement of the sensory properties in Legumes-Milk chocolate with Bioactive rich Plant sources. The second component shows least response for Taste, texture, color and Appearance. The first component accounted for 59.9% and the second component for 18.7% (Figure 9) depicts the outlier's plot. Identification of points within the reference line shows the correlation is significant and Figure 10 represents the score plot of the correlation between the first and second component of the variables Taste, Texture, Color, Aroma, Mouth feel, Flavor, Appearance and Overall Acceptability. The score plot defines the sensory characteristics of legumes-Milk chocolate stating that MOL and SAF added legumes-milk chocolate of Peanut, Red Kidney Bean, Yellow Pea and Chick Pea has low correlation response compared to CML added chocolates. The enriched Double Bean Legumes-Milk chocolate and CML included chocolates with control legumes-Milk chocolates exhibits high correlation thereby indicating the acceptance of chocolate. Significant correlation was found for PN-CML, PN-MOL, PN-SAF, DB-MOL, DB-SAF, RKB-CML, RKB-MOL and RKB-SAF. From the score plot among all correlations, DB-CML exhibits high sensory properties among the bioactive rich source added Legumes-Milk chocolate followed by YP-CML and CP-CML (**Figure 11**) represents the Loading plot for the first two components indicates that every sensory variable has positive correlations and **Figure 12** represents the Biplot.

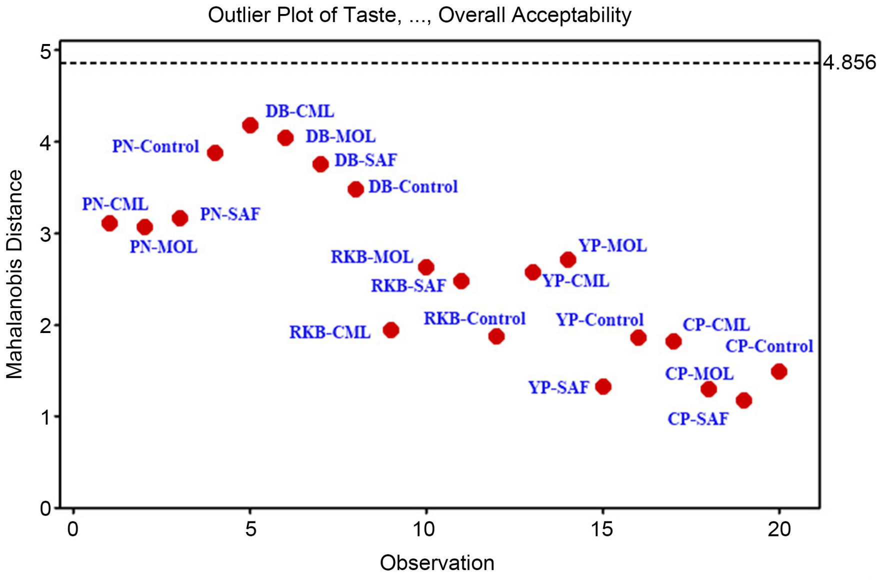

Figure 9. The distribution and correlation between the sensory attributes of Legumes Milk chocolate with Plant Source by Outlier Plot (PN: Peanut, DB: Double Bean, RKB: Red Kidney Bean, YP: Yellow Pea and CP: Chick Pea added with CML: Citron medica leaf powder, MOL: Moringa olifera leaf powder and SAF: Senna auriculata flower powder).

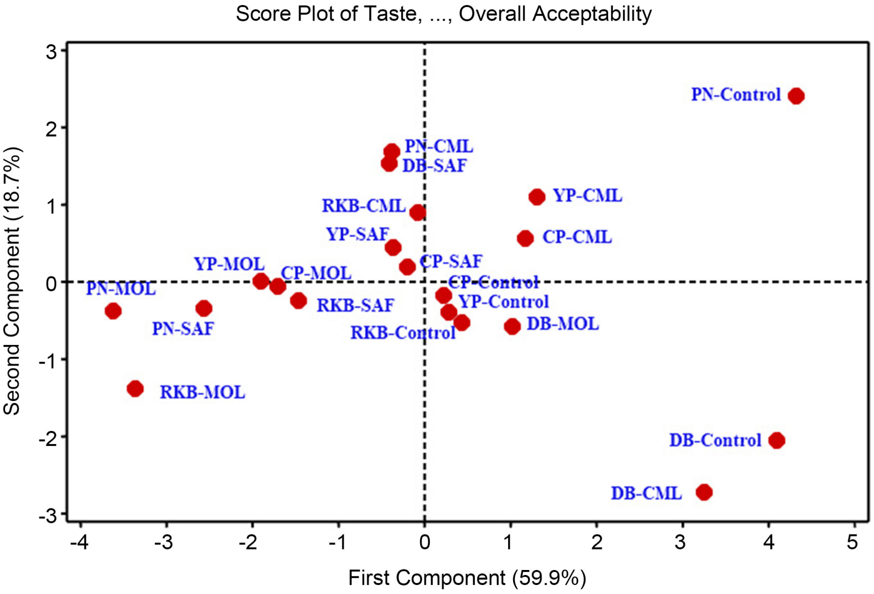

Figure 10. The distribution and correlation between the sensory attributes of Legumes Milk chocolate with Plant Source by Score Plot (PN: Peanut, DB: Double Bean, RKB: Red Kidney Bean, YP: Yellow Pea and CP: Chick Pea added with CML: Citron medica leaf powder, MOL: Moringa olifera leaf powder and SAF: Senna auriculata flower powder).

Table 2. Principal component score of the sensory characteristics of plant source added legumes milk chocolate with control.

Sensory Characteristics Parameters	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Taste	0.415	−0.197	−0.072	0.16	−0.281	−0.684	−0.41	0.208
Texture	0.279	−0.44	−0.586	0.313	−0.227	0.422	0.219	0.095
Color	0.378	−0.197	−0.03	−0.041	0.885	−0.026	−0.008	0.174
Aroma	0.356	0.253	0.502	0.439	−0.108	0.007	0.525	0.277
Mouth feel	0.269	0.623	−0.146	0.164	0.007	0.408	−0.553	0.135
Flavor	0.326	0.349	−0.343	−0.665	−0.138	−0.143	0.38	0.166
Appearance	0.306	−0.389	0.506	−0.459	−0.234	0.407	−0.234	0.113
Overall Acceptability	0.455	0.058	0.049	0.042	−0.004	−0.031	0.047	−0.884

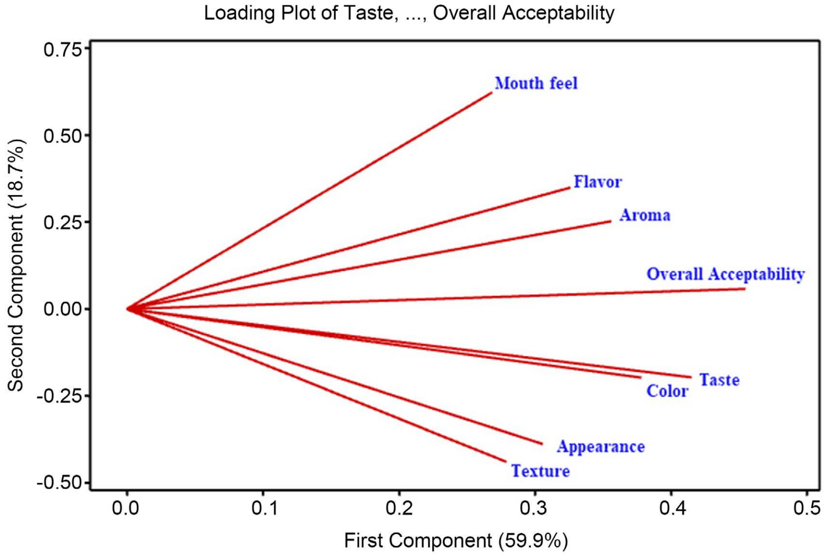

Figure 11. The distribution and correlation between the sensory attributes of legumes milk chocolate with plant source by represented by loading plot.

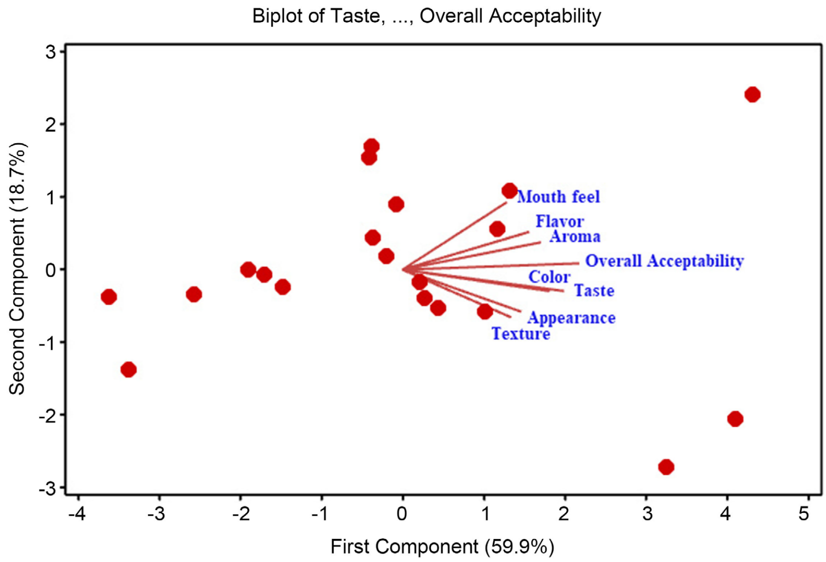

Figure 12. Biplot represents the sensory attributes of plant source added legumes milk chocolate with control.

4. Conclusion

The effect of nutritional and sensory properties was significant on legumes-milk chocolate on the addition of bioactive rich plant sources by PCA. The correlation among the nutritional variables such as proteins, vitamin C, fat, folic acid, carbohydrates, TPC, TFC and Antioxidant Activity with minimal responses of carbohydrates and fats for the reason that the bioactive rich plant source acts as anti-diabetics and antilipidemic. The correlation shows the maximal responses among the variables of sensorial characteristics. Hence the contribution of PCA to explain the nutritional and the sensorial measure of the legumes-milk chocolate on the addition of bioactive rich plant sources assist to enhance the development of the product to commercialize.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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