International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 2943-2948

Received: 13-07-2019
Accepted: 15-08-2019

Nirmalkumar Shanmugasundarm
M Tech, Food Science and Technology, Indian Institute of Food Processing Technology, Thanjavur, Tamil Nadu, India

Dr. VR Sinija
Food Processing Business Incubation Center, Indian Institute of Food Processing Technology, Thanjavur, Tamil Nadu, India

Corresponding Author:
Dr. VR Sinija
Food Processing Business Incubation Center, Indian Institute of Food Processing Technology, Thanjavur, Tamil Nadu, India

Sensory evaluation of functional herbal black tea using fuzzy logic analysis

Nirmalkumar Shanmugasundarm and Dr. VR Sinija

Abstract
The study was aimed at development of herbal based functional black tea to improve the health through addition of the functional bioactive components extracted from the selected indigenous herbs. The different herbs such as leaves of *Coccinia indica*, leaves of *Gymnema sylvestre*, flowers of *Cassia auriculata*, leaves and bark of *Cinnamomum tamala* and seeds of *Trigonella foenum-graecum* were used for the study. The herbal extract was prepared by supercritical fluid extraction with the optimized process parameters of 300 bar pressure, 45˚C temperature, 50 ml modifier and 4 kg/h CO_2 flow rate. Formulation of ready to drink beverage is done by mixing of this herbal extracts in different ratios. The different formulations were evaluated for sensory attributes and the data was analyzed using fuzzy logic techniques. Based on the quality ranking, it was found that ready to drink herbal tea with the addition of 5 mg of extract was ranked first. Also, all the RTD herbal black tea were having high ranks which denotes the product is more preferred and acceptable. Comparing among the quality attributes of the ready to drink tea, it was rated that Character (Taste) > Flavor > Color > Body (Strength), which means character (taste) was the strongest attribute of the tea. Thus, the developed herbal black tea is having good quality characteristics and it will be a new boom for the functional tea market.

Keywords: Herbal black tea, sensory, extraction, fuzzy logic

Introduction
Globally, Tea is the second consumed beverage, other than water (Adam *et al.*, 2017) [1]. Traditionally, custom of tea drinking has been around the world for the past 2000 years and act as refreshing beverage with remarkable health benefits, which is often associated with pleasant aroma and good taste (Sen and Bera, 2013) [2]. Commercially, tea is produced by the fresh young leaves and leaf buds of *Camellia sinensis*, an evergreen plant belongs to the family Theaceae. Much of tea consumed from the *Camellia sinensis* plant, based on the process is categorized into green, black, white and oolong tea depending on fermentation otherwise oxidation process (Chen *et al.*, 2016) [4]. The term fermentation is often used in tea processing should be oxidation, which means exposure to air without any additives during the process (Chan *et al.*, 2010) [3]. These are known as non – herbal teas which are famous among beverage category. Functional tea beverages are now emerging in both hot and cold formats, as many health-conscious consumers are looking for flavorful drinks that will also support a range of systems in body with healing remedies. Owing to the huge demand for functional tea beverages from the consumer is a new way to improve their health rather than depending on medicines. Functional tea production has been increasing and includes several other kinds of plant material besides *Camellia sinensis*. Teas produced from other plant herbs are termed as herbal teas (Chan *et al.*, 2010) [3].

One of the main drawbacks of formulation of herbal teas is that along with providing the nutritional benefits from the herbs included, they also impart their distinct raw flavors, which mostly overpower the characteristics flavor of tea. This reduces the acceptability of the product among the tea consumers when it comes to functional tea-based beverages. This indicates that for more acceptance of the product, the fortification should be in its least level when it comes to sensory properties of the developed product. To achieve this, rather than produce a tea-based beverage along with herb, formulations should be developed with 100% tea supplemented with the necessary herbs as their decoctions/extracts. This not only brings the taste closer to the control sample, without herbs, but also enhances the assimilation process after consumption. The major benefits of herbal based functional beverage are that, the consumer will accept at any cost to improve their health through the functional enrichment.

The selection of such plant herbs is depending on the disease/disorder which commonly seen in consumer. Thus, the extraction of bioactive compounds associated with therapeutic properties of such medicinal plants were utilized.
Commonly used medicinal plants for the treatment of such diseases are *Coccinia indica, Gymnema sylvestre, Cassia auriculata, Cinnamomum tamala and Trigonella foenum-graecum. Coccinia indica* is widely used for reducing the glucose level in Indian traditional medicine. Gymnema sylvestre is indigenous rare herb generally used for the treatment of hyperlipidaemia, Parkinsonism, and hypercholesterolemia. *Cassia auriculata* is a shrub which belong to family Caesalpiniaceae contains flavonoids and phenolic derivatives act as antioxidant. *Cinnamomum tamala* leaves have a clove taste and a fairly pepper odour prepared for the hypoglycaemic and antimicrobial activity. *Trigonella foenum-graecum* known as fenugreek commonly used as legume as well as spice to preserve the quality of foods and considerably known for anti-diabetic and anti-obesity property. These herbs can be utilized in black tea beverage which can be categorized as functional beverage.

Sensory Evaluation using Fuzzy Logic Technique
Fuzzy sets theory allows uncertain phenomena to be treated mathematically. It creates the interface between expert's words and numeric data that allows building numeric – linguistic data. It is adapted to take human linguistic descriptions (not at all satisfactory, fair, good etc.) and reasoning into account. Unlike other theory of sets, according to which a factor belongs to (i.e., 1) or does not belong (i.e., 0) to a set, a fuzzy set is characterized by a function represented by a real number in the interval of 0 and 1. Sensory evaluation is the criteria where the food is accepted or rejected. Usually it is characterized by imprecision, inaccuracy and uncertain repeatability (Sinija and Mishra, 2011) [9]. Subjective evaluation may be involved with single or multiple experts. Expert's opinion will be in linguistic form, which have a lot of vagueness, subjectivity and ambiguity (Shinde and Pardeshi, 2014) [8]. Fuzzy logic is one of the important tool where the linguistic and imprecise data can be analyzed, and decision can be made regarding acceptance, rejection, ranking, strong & weakness of food attributes (Xie, 2016) [11]. The technique can utilize linguistic data from subjective evaluation along with the accurate and precise data available from objective evaluation (Tahsiri *et al.*, 2017) [10].
The purpose of the article is to investigate the sensory quality of the developed functional herbal tea through sensory evaluation and the data were analysed using fuzzy logic techniques. Also aims to find out the strength and weakness of the developed functional herbal beverage.

Materials and Methods
Preparation of samples
The selected herbs such as leaves of *Coccinia indica*, leaves of *Gymnema sylvestre,* flowers of *Cassia auriculata,* leaves and bark of *Cinnamomum tamala* and seeds of *Trigonella foenum-graecum* were procured from locally available herbal plants suppliers in and around Erode, Tamil Nadu. Instant black tea was imported from M/s. One Organic, San Francisco, California. The selected herbal material was prepared and functional compounds was extracted using supercritical fluid extraction. The optimized process parameters at different stages of extraction are 300 Bar pressure, 45˚C temperature, 50 ml modifier and 4 kg/h Co_2 flow rate. The recipe for the formulation of ready to drink herbal black tea was developed with different variance of extracts (1, 3 and 5 mg), 0.1% instant black tea, 9% sugar, 1% acidity regulator (citric acid and ascorbic acid) and 0.1% emulsifier.

Sensory Evaluation
Sensory evaluation of the formulated RTD was carried with the help of twenty judges which includes 10 males and 10 females with different age groups of 21 – 55 years. The selected judges were nonsmokers and non-beetle leaf chewers belonging to staffs, students, faculty, research scholars and trainees of Indian Institute of Food Processing Technology, Thanjavur. The judge's health condition was good and have interests in assessing sensory attributes of RTD teas. Also, the judges were familiar with tea products. Judges were introduced with score sheet; definitions of the quality attributes and sensory scales & scoring pattern were well informed. The judges were asked to have two sniffs and score the flavor first and followed by other quality attributed.
Sensory factors and their numerical values assigned to each quality attributes were poor (0 – 20), fair (21 – 40), good (41 – 60), very good (61 – 80) and excellent (81 – 100). All judges were asked to give their numerical scores corresponding to their samples also along with their quality attributes of RTD teas in general namely, not at all important, important, somewhat important, highly important and extremely important (Sinija *et al.*, 2011) [9].

Comprehensive modeling of sensory scores using fuzzy technique
The main steps involved in fuzzy modeling of sensory evaluation are
- Calculation of overall sensory scores (Triplets Scales – RTD - Samples)
- Calculation of membership function on standard fuzzy scale
- Calculation of overall membership function on fuzzy scale (RTD – Samples)
- Estimation of similarity values and ranking of RTD samples
- Ranking of quality attribute of RTD sample (General)
- Ranking of quality of RTD sample (Individual Samples) (Sinija & Mishra, 2011) [9]

Triplets associated with sensory scales
"Triplet" denotes the set of three numbers which is represented as triangular membership function distribution pattern of sensory scales. Figure 1 shows the distribution pattern and Table 1 shows triplets associated with five-point sensory scales.

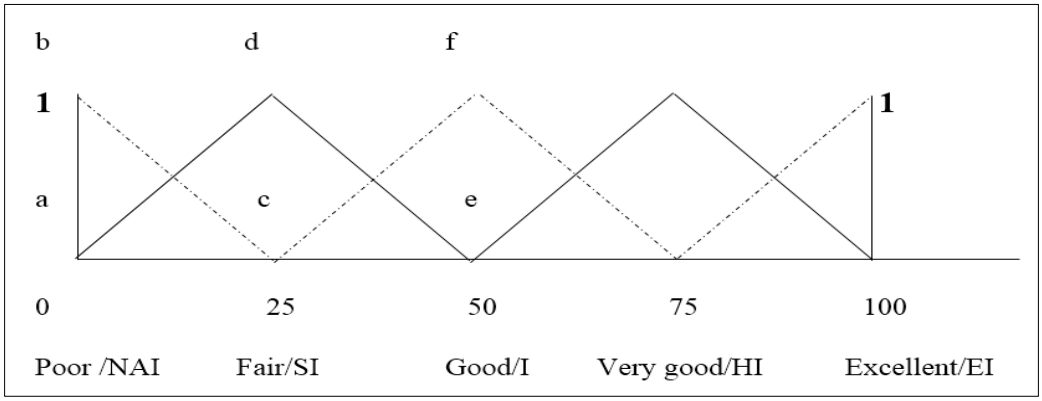

Fig 1: Triplets associated with five-point sensory scales

Table 1: Triplets associated with five-point sensory scales

Poor / Not at all important	Fair / Somewhat important	Good / Important	Very good / Highly important	Excellent / Extremely Important
0 25 25	25 25 25	50 25 25	75 25 25	100 25 0

Triplets for sensory scores of RTD samples and overall quality

Triplets corresponding to the quality attributes can be obtained from the sum of the sensory scores and triplets associated with sensory data and the number of judges. For example, colour, the triplets for the sensory scores will be given following eq. (1.1)

$$S1C = \frac{0\,(0\,0\,25) + 1(25\,25\,25) + 2\,(50\,25\,25) + 8\,(75\,25\,25) + 5\,(100\,25\,0)}{(0+1+2+8+5)} \quad \ldots(1.1)$$

Similarly, the triplet values can be calculated by replacing the values on quality attribute in general. To find out the overall sensory scores, sensory scores of each attribute was multiplied with triplet of relative weightage. The overall sensory score for sample one is given eq. (1.2)

$$SO_1 = S_1C \times QC_{rel} + S_1F \times QF_{rel} + S_1T \times QT_{rel} + S_1S \times QS_{rel} \quad \ldots(1.2)$$

where S_1C, S_1F, S_1T and S_1S where triplets of quality attributes of samples and QC_{rel}, QF_{rel}, QT_{rel}, QS_{rel} where relative weightage of the triplets.

The matrix multiplication of two triplets, rule where given in the equation (1.3)

$$(a\ b\ c) \times (d\ e\ f) = (a \times d\ a \times e + d \times b\ a \times f + d \times c) \quad \ldots(1.3)$$

Standard fuzzy scales – Membership function

Symbols F1, F2, F3, F4, F5 and F6 represents the sensory scales. Values of membership function of F1 through F6 are defined by a set of 10 numbers as follows in eq. (1.4)

F1 = (1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0)
F2 = (0.5, 1, 1, 0.5, 0, 0, 0, 0, 0, 0)
F3 = (0, 0, 0.5, 1, 1, 0.5, 0, 0, 0, 0)
F4 = (0, 0, 0, 0, 0.5, 1, 1, 0.5, 0, 0)
F5 = (0, 0, 0, 0, 0, 0, 0.5, 1, 1, 0.5)
F6 = (0, 0, 0, 0, 0, 0, 0, 0, 0.5, 1)

…(1.4)

Overall membership function of sensory score on standard fuzzy logic scale

For each sample and its triplets, value of membership function B_x at x = 0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 was calculated. This membership function value of samples on standard fuzzy scale will be given as a set of 10 numbers which are "(maximum value of B_x at $0 < x < 10$), (maximum of B_x at $10 < x < 20$), (maximum value of B_x at $20 < x < 30$), (maximum value of B_x at $30 < x < 40$), (maximum value of B_x at $40 < x < 50$), (maximum value of B_x at $50 < x < 60$), (maximum value of B_x at $60 < x < 70$), (maximum value of B_x at $70 < x < 80$), (maximum value of B_x at $80 < x < 90$), (maximum value of B_x at $90 < x < 100$)."

Similarity values and ranking of RTD tea samples

Once B is obtained for each sample on standard fuzzy scale of set of 10 values, the similarity for each sample was obtained by the eq. (1.5)

$$S_m(F, B) = \frac{F \times B'}{\text{Max}\,(F \times F' \text{ and } B \times B')} \quad \ldots(1.5)$$

Where, S_m is the similarity value for the sample, F X B' is the product of matrix F with the transpose of matrix B, F X F' is the product of matrix F with the transpose of F and B X B' is the product of B matrix B with its responses. Thus, for other samples similarity values can be calculated. Using the matrix multiplication rule the values are calculated.

Similarity values under the six functions of sensory scales were compared to find out the highest similarity value. The same method mentioned above was used for quality attribute ranking in general and also for individual RTD samples.

Determination of tea constituents of RTD Herbal Black Tea

The developed RTD herbal black tea was analyzed for tea active constituents such as Theaflavin (TF), Thearubigins (TR), Highly Polymerized Substances (HPS), Total Polyphenols (TP) and Total Liquor Colour (TLC) as per method prescribed by UPASI Tea Research Institute, Ooty. The methodology of the determination of TF/TR/HPS/TP/TLC were showed in the Figure 2.

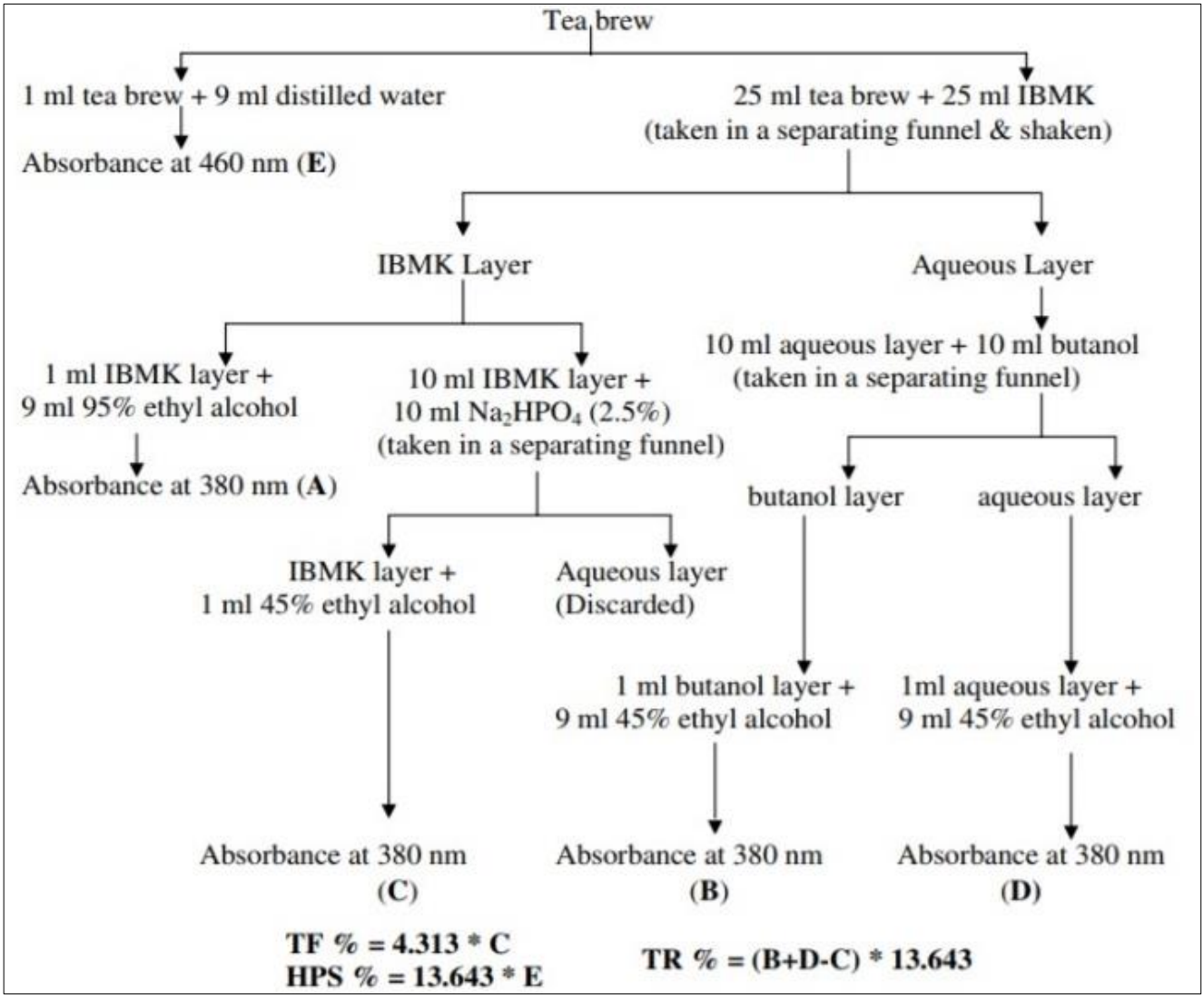

Fig 2: Methodology for determination of TF/TR/HPS/TP/TLC

Determination of β-sitosterol in RTD functional beverage.
The plant sterol, β-sitosterol for the formulated RTD functional beverage were analyzed using HPTLC. The sample were evaporated, and saponification of residues were carried out for the beta-sitosterol estimation. Beta-sitosterol reference compound were used as standard for linearity calibration using High-Performance Thin Layer Chromatography (Dharmender *et al.*, 2010; Jirge *et al.*, 2011) [6, 7].

Result and Discussion

Sensory Evaluation of Formulated RTD Herbal Black Tea

Sensory evaluation of the formulated RTD herbal black tea samples control, F1, F2 & F3 along with one RTD black tea commercially available in market (for comparison) was carried out.. The samples were decoded, F3 as XSH (Sample 1), F2 as DFY (Sample 2), F1 as IKJ (Sample 3), control as IUO (Sample 4) and market sample as QNM (Sample 5). The Table 2 shows the sensory preferences given by the judges for the formulated samples as described in decoded form. The triplets associated with the sensory scores of each sample was calculated by the method described in the materials and methods.

The sensory scores considered for attributes in general were not at all important (NI), somewhat important (SI), important (I), highly important (HI) and extremely important (EI). The considered attributes colour, flavor, character and body were calculated in similar manner for sensory scores of samples. The triplets associated with attributes and the relative weightage are presented in Table 3.

The overall sensory scores of each sample can calculated by using eq. 1.3. The values of triplets in sensory scores, attributes and relative weightage were multiplied by rule mentioned and in eq. 1.4.

The overall sensory score triplets were calculated which is presented below.

SO_1 = 56.4854 42.3849 36.9874
SO_2 = 67.6569 48.1172 37.1548
SO_3 = 55.2301 42.2594 36.9874
SO_4 = 64.1841 46.4435 39.7699
SO_5 = 59.4939 40.8882 36.2493

Table 2: Preferences by judges for samples and triplets corresponding to the scores

Sensory attributes	Poor	Fair	Good	V. Good	Excellent	Triplets for sensory scores
Color & Appearance						
Sample 1	1	2	6	8	3	S1C = (62.5 23.75 21.25)
Sample 2	2	0	11	5	2	S2C = (61.25 25 22.5)
Sample 3	0	0	12	6	2	S3C = (55 23.75 21.25)
Sample 4	0	1	8	9	2	S4C = (65 25 23.75)
Sample 5	2	6	8	4	0	S5C = (59.38 23.61 25.02)
Flavour						
Sample 1	0	3	7	8	2	S1F = (56.25 22.5 22.5)
Sample 2	1	2	8	6	3	S2F = (60 23.75 21.25)
Sample 3	0	0	9	6	5	S3F = (61.25 25 22.5)
Sample 4	0	1	3	10	6	S4F = (65 25 22.5)
Sample 5	5	4	8	3	0	S5F = (29.52 21.74 25.1)
Character (Taste)						
Sample 1	1	2	12	2	3	S1CH = (62.5 25 22.5)
Sample 2	2	3	9	4	4	S2CH = (70 25 18.75)
Sample 3	0	1	7	7	5	S3CH = (70 25 17.75)
Sample 4	0	2	2	11	5	S4CH = (62.5 25 25)
Sample 5	3	7	5	5	0	S5CH = (60.12 25 21.65)
Body (Strength)						
Sample 1	0	0	9	10	1	S1B = (42.5 22.5 25)
Sample 2	0	1	8	9	2	S2B = (36.25 18.75 25)
Sample 3	0	1	8	11	0	S3B = (40 21.25 25)
Sample 4	0	0	7	12	1	S4B = (43.75 22.5 25)
Sample 5	2	3	13	2	0	S5B = (45.89 23.85 25)

Table 3: Preferences by judges for attributes and associated triplets

Quality attributes	NI	SI	I	HI	EI	Triplets for sensory scores	Triplets for relative weightage
Color	0	0	9	8	3	C = (61.85 25 20.86)	(0.215 0.084 0.079)
Flavor	0	0	2	10	8	F = (86.75 25 15.89)	(0.299 0.083 0.051)
Character	0	1	1	15	3	CH = (83.74 25 16.65)	(0.284 0.083 0.052)
Body	0	1	4	10	5	B = (58.98 25 21.73)	(0.210 0.089 0.074)

Overall membership functions on standard fuzzy scale

The six standard fuzzy function mentioned in the materials and methods section and based on criteria given the overall membership functions (B) of each sample were calculated which is given below.

B_1 = (0 0.1038 0.3252 0.5466 0.7680 0.9894 1 0.7423 0.4715 0.2008)

B_2 = (0 0.899 0.3115 0.5330 0.7546 0.9761 0.9761 0.7563 0.4832 0.2101)

B_3 = (0 0.0219 0.2312 0.4405 0.6498 0.8591 0.9111 0.9111 0.6392 0.3672)

B_4 = (0 0 0.1646 0.3673 0.5699 0.7726 0.9753 0.9753 0.7637 0.4645)

B_5 = (0.1288 0.4145 0.7002 0.9860 0.9860 0.7265 0.4388 0.1512 0 0)

Similarity values of samples and their ranking

The similarity values for samples were calculated using the values of membership functions of standard fuzzy scale and overall membership functions of sensory scores. The similarity values for each sample were calculated which is shown in Table 4**.**

From the Table 4, comparing the highest similarity values it is shown that sample 1, sample 2, sample 3 and sample 4 were in "good" category. Sample 5 is under "satisfactory" category. Based on the samples having highest similarity values the ranking were given in the order sample 1 > sample 2 > sample 3 > sample 4 > sample 5. Sample 1 is the formulation F3, which is the RTD herbal black tea sample with addition of 5 mg of prepared herbal extract obtained through supercritical fluid extraction in the tea. So, the product formulation is fixed as F3. Though it is good category, further it can be improved by addition of extract (Sinija *et al.*, 2011) [9]. The ranking of the samples also shown all RTD herbal black tea were having high ranks which denotes the product is more preferred and acceptable.

Table 4: Similarity values of samples and ranking

Sensory Scales	Sample 1 (F3)	Samtple 2 (F2)	Sample 3 (F1)	Sample 4 (Control)	Sample 5 (Market)
Not satisfactory, F1	0.0137	0.0120	0.0028	0	0.0876
Fair, F2	0.1849	0.1776	0.1222	0.0826	0.4356
Satisfactory, F3	0.5193	0.5167	0.4404	0.3603	0.6352
Good, F4	0.7263	0.7227	0.6948	0.6516	0.5230
Very Good, F5	0.4777	0.4873	0.5652	0.5866	0.0966
Excellent, F6	0.1149	0.1201	0.1773	0.2078	0
Ranking	I	II	III	IV	V

Quality ranking of sensory attributes

Similarly, the values of the membership functions and similarity values for tea quality attributes were calculated and which is presented in the Table 5. By comparing the values shown that similarity value for character or taste (0.95120) is the highest followed by flavor (0.8778) and these two

parameters are extremely important and highly important respectively. This is followed by color (0.8597) and body or strength (0.8597) these attributes are under important category. Therefore, based on the preference order the ranking was given in the order Character (Taste) > Flavor > Color > Body (Strength). For any kind of tea, the character, flavor, color are the most important attributes in general (Sinija *et al.*, 2007; Sinija *et al.*, 2011) [9, 11].

Determination of tea constituents

Based the sensory evaluation, the formulation F3, RTD herbal black tea was selected and the active tea constituents present in the RTD herbal black tea were analyzed. The results tea constituents such as Theaflavin (TF), Thearubigins (TR), Highly Polymerized Substances (HPS), Total Polyphenols (TP), Total Liquor Colour (TLC), TF:TR ratio were shown in Table 6.

Table 5: Similarity values of quality attributes and ranking

Factors	Color	Flavor	Character	Body
Not at all important	0.0000	0.0000	0.0000	0.0000
Somewhat important	0.0000	0.0000	0.0025	0.0000
Necessary	0.0385	0.0125	0.0087	0.5163
Important	0.8597	0.6787	0.5013	0.7852
Highly important	0.5275	0.8778	0.2567	0.6689
Extremely important	0.7289	0.5343	0.9512	0.5268
Ranking	III	II	I	IV

Table 6: Tea constituents present in RTD herbal black tea

Tea constituents	Formulation, F3
Theaflavins, %	0.681
Thearubigins, %	8.20
Highly polymerized substances, %	12.61
Total polyphenols, %	23.98
Total liquor colour	3.70
TR:TF Ratio	12.04

The observed results shown theaflavin and thearubigins content of the formulated F3 RTD herbal black tea is 0.681% and 8.20%. Theaflavins are orange red substances that results for the brightness, briskness and color of the tea beverage whereas thearubigins are condensation products of oxidized catechins. Thus, TR contributes for mouthfeel and strength of the tea beverage. Usually, for good quality of tea the TR:TF ratio should be within 10 – 12 (Sinija *et al.*, 2007) [12]. The observed TR:TF ratio for the formulated RTD herbal black tea beverage is 12.04, it is within the limit for good quality of tea.

Highly polymerized substances together react with TR, will contributes mouthfeel of the tea. The observed values of HPS of the formulated beverage is 12.61%. The total liquor color is 3.70 for the formulated beverage, this shown the orange red colour due to presence of theaflavins in the tea beverage.

Determination of β-sitosterol in RTD Functional Beverage

The β-sitosterol content in formulated RTD herbal black tea was found to be 0.25%. The observed result confirms that extract incorporated to the RTD beverage has plant sterols in it. On consumption of this RTD herbal black tea, it has additional benefits of plant sterols. Thus, it acts as the functional beverage.

Conclusion

Sensory evaluation was carried out for the developed functional herbal black tea beverage by panel of 20 judges and the sensory data was analysed using fuzzy logic technique. The developed sample was compared with control sample (without extract) and commercial market ready to drink tea samples. It was found that ready to drink herbal tea with the addition of 5 mg of extract was ranked first. Also, all the RTD herbal black tea were having high ranks which denotes the product is more preferred and acceptable. The quality attributes of the ready to drink tea was rated as Character (Taste) > Flavor > Color > Body (Strength), which means character (taste) was the strongest attribute of the tea. Also, major active tea constituents is present in the required ratio along with additional benefits of plant sterols.

References

1. Adam AZ, Lee SY, Mohamed R. Pharmacological properties of agarwood tea derived from Aquilaria (Thymelaeaceae) leaves: An emerging contemporary herbal drink. Journal of Herbal Medicine, 2017. DOI: 10.1016/j.hermed.2017.06.002
2. Sen G, Bera B. Black tea as a part of daily diet: A boon for healthy living. International Journal of Tea Science. 2013; 9(October):51-59.
3. Chan EWC, Lim YY, Chong KL, Tan JBL, Wong SK. Antioxidant properties of tropical and temperate herbal teas. Journal of Food Composition and Analysis. 2010; 23(2):185-189. DOI: 10.1016/j.jfca.2009.10.002
4. Chen G, Yuan Q, Saeeduddin M, Ou S, Zeng X, Ye H. Recent advances in tea polysaccharides: Extraction, purification, physicochemical characterization and bioactivities. Carbohydrate Polymers. 2016; 153:663-678. DOI: 10.1016/j.carbpol.2016.08.022
5. Das H. Food processing operations analysis pp. 383-402. New Delhi: Asian Books, 2005.
6. Dharmender R, Madhavi T, Reena A, Sheetal A. Simultaneous Quantification of Bergenin, (+)-Catechin, Gallicin and Gallic acid; and Quantification of β-Sitosterol using HPTLC from *Bergenia ciliata* (Haw.) Sternb. Forma ligulata Yeo (Pasanbheda). Pharmaceutica Analytica Acta, 2010, 01(01). DOI: 10.4172/2153-2435.1000104
7. Jirge SS, Tatke PA, Gabhe SY. Development and Validation of a Novel Hptlc Method for Simultaneous Estimation of Beta - Sitosterol - D - Glucoside and Withaferin a. 2011; 3:9-12.
8. Shinde KJ, Pardeshi IL. Fuzzy Logic Model for Sensory Evaluation of Commercially Available Jam. 2014; 1(2):78-84.
9. Sinija VR, Mishra HN. Fuzzy Analysis of Sensory Data for Quality Evaluation and Ranking of Instant Green Tea Powder and Granules, 2011, 408-416. DOI: 10.1007/s11947-008-0163-x
10. Tahsiri Z, Niakousari M, Seyed SKN, Hosseini MH. Sensory evaluation of selected formulated milk barberry drinks using the fuzzy approach. 2017; (October 2016):1-11. DOI: 10.1002/fsn3.454
11. Xie J. Research Article A Novel Fuzzy Mathematical Method to the Sensory Evaluation of Wine Jinyun Xie Changsha Vocational and Technical College, Changsha, 410010, China. 2016; 10(5):343-347. DOI: 10.19026/ajfst.10.2079
12. Sinija VR, Mishra HN, Bal S. Process technology for production of soluble tea powder. 2007; 82:276-283. DOI: 10.1016/j.jfoodeng.2007.01.024