International Food Research Journal 24(2): 703-710 (April 2017)
Journal homepage: *http://www.ifrj.upm.edu.my*

Sensory evaluation of probiotic whey beverages formulated from orange powder and flavor using fuzzy logic

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Article history

Received: 4 October 2015
Received in revised form: 3 April 2016
Accepted: 8 April 2016

Keywords

Fermented whey beverages
Organoleptic quality
Probiotic
Fuzzy analysis

Abstract

Modern fermented whey beverages are expected by the consumer to deliver reliable organoleptic quality and safety from disease causing pathogenic organism and presence of live probiotic bacteria to fulfill the associated nutritional, probiotic and therapeutic benefits. The sensory evaluation of three samples of whey beverages (S1, S2, and S3) fermented with probiotic culture followed by addition of orange powder and orange flavor was done with respect to one standard brand of whey beverage (S4) available in market. This study was performed to analyze the sensory scores of the various samples of the whey beverages, rank the different samples according to their sensory qualities and also to rank general quality attributes like color, flavor, and texture and taste using fuzzy analysis. After analyzing the sensory parameters obtained from a panel of 11 judges, the ranking of the probiotic whey beverage samples was following S3>S2>S1>S4 respectively. Standard market whey beverage S4 was ranked the last. The ranking for the general quality attributes was Color > Flavor > Texture > Taste..

Introduction

Whey is the liquid remaining after the curdling and straining of milk. During the manufacture of cheese or casein it is obtained as a by-product and can be utilized for several commercial purposes. Sweet whey is obtained during the manufacture of hard cheese like cheddar cheese or swiss cheese, whereas acid whey is obtained during the manufacture of cottage cheese. Whey protein is enriched in α-lactalbumin and β-lactalbumin and sometimes it may also contain glycomacropeptides depending on the method of manufacture. Whey can be utilized as an additive in many processed foods like breads, crackers, commercial pastry and different animal feeds. It can also be utilized as a whey beverage or probiotic whey beverage incorporated with different types of powder and flavor as obtained from various functional fruits and vegetables. Normally thrust increases due to the loss of fluids because of exertion, temperature or age, which leads to loss of nutrients like electrolytes, vitamins, lactates, amino acids and other organic components. The lost organics and in organics with the extracellular fluid can be replaced by the consumption of whey beverage. Compared to most of the available soft beverages, whey is a genuine thirst quencher. Unlike other beverages, whey beverages are less acidic, light and refreshing. So, it can be consumed as a soft beverage superior over other available beverages due to its rapid digestibility and fulfillment of lost organic and in organic nutrients with the extracellular fluids (Prendergast 1985).

In order to develop acceptable long life beverages whey having high medicinal and nutritional value is added with different types of fruit juices or pulp and concentrates. For utilization of the nutrients the application can be considered as the most obvious and logical opportunity into the human food chain. In order to develop acceptable whey based fruit beverages, it is required to mix fruit juices and minimally processed whey with suitable stabilizers and acidulants in the manufacturing process of whey –fruit juice based beverages (Singh *et al*., 2005). Recently probiotic beverages are considered as the key development segment for the exploitation of minimally processed whey. In order to provide a positive impact in the host followed by the upgrading of the properties of the indigenous beneficial microbiota, some probiotic lactic acid bacteria in addition to fermentation process can be considered as the dietary source of living organism. Health benefits like reduction of serum cholesterol, alleviation of lactose intolerance, reduction of cancer risk, and resistance to enteric pathogens, among others due to the ingestion of probiotics make it an emerging additive in order to make functional food products or

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beverages (Klaenhammer, 1998).

Consumption of dairy products incorporated with health beneficial probiotic bacteria has increased worldwide over the last two decades. Generally incorporation of selected strains of *Bifidobacteriu*m spp. and *Lactobacillus* spp. into fermented dairy products are the most highlighting concern. In this study, for making probiotic whey-fruit beverage these two strains are used as the culture media in the fermentation process. In addition to this, satisfying the demands of the consumers is a major issue in order to succeed in promoting the consumption of functional probiotic products. For deciding the consumer choice towards the food products, sensory parameters followed by the nutritional properties are required to be considered. Due to this reason, sensory analysis of any developed food product is an important concern prior to supply the product in the market (Routray and Mishra, 2011).

Knowledge gained through individual sensation is the key parameter for the evaluations in any field. But in case of sensory evaluation, it is very problematic to model and manage the knowledge gained by sensation. It is due to the fact that involvement of uncertainty and imprecision in case of acquiring information by human senses makes it difficult for the evaluation of the sensory data (Martinez, 2007). In order to accept or reject any food product based on potency and fault of specific sensory attribute followed by the statiscal analysis of the sensory data like color, flavor, taste and mouth-feel is not possible. In this regard, researchers have found out the implementation of fuzzy logic (expressed in linguistic terms of operators and experts) for the sensory analysis of the food product (Perrot *et al.*, 2006). A developed product can be compared with the similar product available in the market by implementing the fuzzy logic technique. This technique can also be utilized to rank different product samples evaluated by judges and to determine the quality of the product influenced by different factors. As a result of which development and improvement of the emerging food products becomes easier due to the identification and improvement of the most important factors required for a particular market (Jaya and Das, 2003).Sensory analysis of many food products like mango beverage (Jaya and Das 2003) and coffee (Lazim and Suriani, 2009) have been studied by using fuzzy logic.

In this study, the sensory properties of reconstituted probiotic whey beverages obtained by mixing cheese whey, sugar, sodium-citrate stabilizer, orange powder and flavor were compared with the standard whey beverage reconstituted from cheese whey, sugar and stabilizer where amount of total solid and sugar was same for each case. By using fuzzy logic ranking of different beverage samples were done in order to find out overall acceptance of different beverage compositions and the relative importance of the different sensory attributes color, flavor, texture and taste. In this study, the highlighting factors were utilization of orange powder and flavor as probiotic and finally to find out effect of different constituents on the sensory properties of the developed whey-fruit beverage.

Methods and Materials

Materials required

All the materials were made available in the laboratory. Fresh cheese whey as obtained from the manufacturing of cheddar cheese was used as raw material for the beverage preparation. Commercially available good quality cane sugar procured from the local market was used as sweetener. For the stabilization of the developed mixture sodium citrate was used. Good quality orange powder and flavor were collected from the local market. Thermophilic lactic culture (FD-DVS ABY-3) [CHR HANSEN, Denmark] supplied in convenient freeze dried form, was used. Glass wares and culture media were made available in the laboratory.

Equipments required

For making the probiotic whey beverages pH meter, inoculation chamber, incubator, electronics balance, electric oven, autoclave, Gerber centrifuge, spectrophotometer, thermometer and refractrometer were made available in the laboratory.

Probiotic whey beverage preparation

For the preparation of proboitic whey beverage, 1 liter fresh cheddar cheese whey was used. Then filtration was done by using 4 layer of muslin cloth. After that stabilizer (0.70 gm per liter of sodium citrate) and sugar (8%) was added followed by mixing with the help of blender. After blending, pasteurization was carried out at 70^0C for 15 minutes in order to kill unwanted microorganism followed by cooling up to 42^0C. For the preparation of culture inoculum thermophilic lactic culture (FD-DVS ABY-3) in freeze dried form was used. The culture was defined as mixed strain culture containing LA-5 *Lactobacillus acidophilus*, BB-12 *Bifidobacterium* and *Streptococcus thermophilus*. From the prepared culture inoculum, 2 ml of culture inoculums were inoculated in pasteurized whey by maintaining the temperature at 42^0C. Then incubation was carried at 42^0C up to an optimum pH range of 4.3-4.5. It was

observed that 4 hours were required for reaching the optimum pH range. After this step, orange powder (1%) and orange flavor were added in the inoculated mixture by maintaining a final pH of 4.3. Final product was filled in sterilized glass bottles and bottles were re-pasteurized by putting them in water bath at 90^0C for 5-7 minutes.

Preparation of different beverage samples

For the sensory evaluation of the probiotic whey beverage three samples were prepared. These were as follows: 1) Sample 1-1 litre cheese whey + 0.70 gm stabilizer + 8% sugar + 1% orange powder + 0.20 ml flavor. 2) Sample 2-1 litre cheese + 0.70 gm stabilizer + 8% sugar + 1% orange powder + 0.30 ml flavor. 3) Sample 3-1 litre cheese + 0.70 gm stabilizer + 8% sugar + 1% orange powder + 0.40 ml flavor. For comparison of the developed products a standard sample (sample 4) was also prepared with the combination of whey, sugar and stabilizer. In this sample probiotic was not added. So the whey beverage (sample 4) was compared with different samples of probiotic whey beverages (sample 1, sample 2 and sample 3) in order to find out the effect on the sensory properties of the developed product.

Sensory evaluation of probiotic whey beverages

By considering good health, interests in sensory evaluation, knowledge of the product and eagerness to participate on a regular basis, a panel of 11 judges was formed followed by the familiarization of the characteristics of good quality whey beverage and the meaning of different terminologies used (Jaya and Da, 2003).

The definition of selected quality attributes, format of score sheet and method of scoring were discussed to all the judges. During the interval between 10–12 am and 3–5 pm judging was done. Between tasting the consecutive samples, the judges were recommended to take water of puffed rice (Jaya and Das, 2003). After the evaluation of the samples judges are instructed to give tick mark in the respective fuzzy scale factor for each of the sensory parameter. The attributes like "Not satisfactory," "Fair,", "Medium," "Good" and "Excellent" were used for rating the samples. Fuzzy comprehensive modeling was utilized for the sensory analysis observation data. For mango beverages (Jaya and Das 2003), instant green tea powder (Sinija andMishra, 2011) and dahi powder based beverages (Routray and Mishra, 2011) this method had been implemented till now.

Fuzzy comprehensive modeling of the sensory score

Linguistic data based on subjective evaluation and accurate and precise data based on objective evaluation are utilized by this method. Triangular fuzzy membership distribution function was used for the ranking of the whey beverage samples (Das, 2005). Fuzzy score card was used for obtaining the sensory scores of the samples. In order to rank the samples similarity values were estimated by using triplet value obtained from sensory scores of different samples. Sensory analysis using fuzzy logic mainly consists of five steps: (1) Determination of triplets on the basis of overall sensory scores of whey beverages (2) Membership function estimation by using standard fuzzy scale; (3) Utilization of standard fuzzy scale for the computation of overall membership function. (4) Ranking of the whey beverages samples followed by estimation of similarity values. (5) General ranking on the basis of quality attributes of whey beverages.

Calculation of triplets for sensory scores of whey beverages and overall quality

Based on the sum of sensory scores, triplets associated with sensory scale and number of judges the triplet of sensory scores for every quality attribute of a particular sample was determined. For example, we need to find out the triplets for sensory scores of color attribute. In this case, if total numbers of judges are $(n_1 + n_2 + n_3 + n_4 + n_5)$ and "Not satisfactory" score is given by n1, "Fair" score is given by $_{n2}$ judges, "Medium "score is given by n_3 judges, "Good" score is given by n_4 judges and "Excellent" score is given by n_5 judges, then the triplets for the sensory scores for color will be calculated as follows:

$$C= \frac{n_1(0\ 0\ 25)+n_2(25\ 25\ 25)+n_3(50\ 25\ 25)+n_4(75\ 25\ 25)+n_5(100\ 25\ 0)}{n_1+n_2+n_3+n_4+n_5}$$

After calculating triplet values obtained for each of the quality attributes of all the samples, the triplet for the sensory score of quality attributes were calculated from the general weightage given by the judges. By multiplying the triplet for relative weightage of that particular attribute and the sum of resultant triplet values for all attributes, triplets for the overall sensory scores of 'whey beverages' samples were calculated. For any sample number "r", the formula can be written as follows:

$$SO_r = S_rC * QC_{rel} + S_rA * QA_{rel} + S_rT * QT_{rel} + S_rH * QH_{rel}$$

Where C is for color, A is for aroma, *T* is for taste, H is for homogeneity and "*" is the symbol

for multiplication. The overall scores for all samples were calculated by using the same equation.

For multiplication of triplets, like triplet (a b c) with triplet (d e f), the equation can be written as:

$$(a\ b\ c) * (d\ e\ f) = (a * d\ \ a * e + d * b\ a * f + d * c)$$

Estimation of membership function for standard fuzzy scale

Standard fuzzy scale in the form of triangular distribution pattern of 6-point scale is shown in figure 3. Here the symbols F1, F2, F3, F4, F5 and F6 represent sensory scale. Triangular distribution pattern is followed by each of the membership function of the sensory scale with a value of membership function of 1. Each of the sensory scale with a set of 10 numbers can be written as follows:

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)

Computation of overall membership function of sensory scores on standard fuzzy logic scale

Graphical representation of membership functions of a triplet (a, b, c) and triplet are represented by figure 4. Triplets associated with overall sensory scores were calculated using Eq. 5. In case of abscissa having value of a for a triplet (a,b,c), the value of membership function is 1, whereas for the abscissa having value less than a–b or greater than a + c the membership function is zero. If the abscissa value is x, then we can write the following expression:

$$Bx = \frac{x-(a-b)}{b} \quad \text{for (a-b)<x<a}$$

$$= \frac{(a+c)-x}{c} \quad \text{for a<x<a+}$$

Estimation of similarity values and ranking of the whey beverages' samples

The similarity values for each sample were calculated on the basis of B values for each of the samples obtained on standard fuzzy scale as a set of 10 values. It is expressed by the following equation:

$$Sm(F,B) = \frac{F * B'}{Max\ (F * F' and\ B * B')}$$

Thus, by using matrix multiplication similarity values for the first sample (Sm (F1, B1), Sm (F2, B1), Sm (F3, B1), Sm (F4, B1), Sm (F5, B1) and Sm (F6, B1)) values were calculated followed by the categorization of the sample having maximum similarity value. In this way, grading of the overall quality of the samples was done.

Similarity Values for Quality Attribute Ranking of the Whey Beverages in General

Ranking for the quality attributes of the beverages in general and also individual beverage sample was done by using same method. Fuzzy logic evaluation of the sensory data was done by using MATLAB R2012a program (Das, 2005).

Results and Discussion

It was observed that sensory responses for different samples varied in a wide range. These responses were presented as the sensory score (Table 2) followed by the sum of the number of judges with different preference levels for the different quality attributes of the samples. The symbols NS, FR, MD, GD and EX were used for designating sensory scale parameters as not satisfactory, fair, medium, good and excellent respectively. It can be observed that S3 has been considered as Good/Excellent by most of the judges present in the panel.

It can be observed that S4 has been ranked as Good/Excellent by greater proportion of the judges. The triplets associated with sensory scales and the sensory scores given by the judges as calculated by using the Eq. 1 are represented in table 2 for all the samples (S1, S2, S3 and S4). For example, S1C = (43.181, 20.454, 22.727), S1F = (47.727, 22.727, 22.727), S1X = (47.727, 20.454, 25) and S1T = (65.909, 25, 20.454) were calculated s triplets associated with the quality attributes color, flavor, texture and taste of sample 1 (Table 2).

Not at all important (NI), somewhat important (SI), important (IM), highly important (HI) and extremely important (EI) were considered as the sensory scores/scales in general for quality attributes. Table 3 represents the sum of the judges with different preference levels (sensory scales) of the quality attributes. It can be observed that color could be the most important quality attribute among the four attributes in the case of whey beverage as 6 out of 11 judges have ranked color as extremely important parameter. After the calculation of the similarity values for the quality attributes of the different beverages, it would be verified. By following the same pattern of sensory scores of all the samples as previously presented (Table 3), sensory scores of all the quality attributes like color, flavor, texture and taste, in general were calculated. By employing Eq. 2 overall sensory scores of each of the samples were estimated. Triplets for sensory scores of whey

Table 1. Sum of the number of judges with different preferences and triplets associated with the sensory scores for the quality attributes of whey beverages

Sensory quality attributes of whey beverages	NS	FR	MD	GD	EX		Triplets of Sensory Scores		
Color									
S1	2	4	1	3	1	S1C	43.18	20.45	22.72
S2	0	0	2	5	4	S2C	47.72	22.72	22.72
S3	0	0	1	3	7	S3C	47.72	20.45	25
S4	2	4	2	2	0	S4C	65.90	25	20.45
Flavor									
S1	1	2	6	1	1	S1F	79.54	25	15.90
S2	0	2	3	6	0	S2F	59.09	25	25
S3	0	0	0	1	10	S3F	77.27	25	18.18
S4	1	4	4	4	0	S4F	79.54	25	15.90
Texture									
S1	2	1	4	4	0	S1X	88.63	25	9.09
S2	0	0	2	6	3	S2X	97.72	25	2.27
S3	0	2	2	2	5	S3X	72.72	25	13.63
S4	1	1	3	5	1	S4X	75	25	15.90
Taste									
S1	0	2	2	5	2	S1T	31.81	18.18	22.72
S2	0	0	2	5	4	S2T	54.54	27.27	29.54
S3	0	2	0	5	4	S3T	59.09	22.72	22.72
S4	1	3	4	3	0	S4T	45.45	22.72	25

EX, excellent; FR, fair; GD, good; MD, medium; NS, not satisfactory; S1, sample 1; S2, sample 2; S3, sample 3; S4, sample 4; S1C, triplet associated with the quality attribute color of sample 1; S2C, triplet associated with the quality attribute color of sample 2; S3C, triplet associated with the quality attribute color of sample 3; S4C, triplet associated with the quality attribute color of sample 4; S1F, triplets associated with the quality attribute flavor of sample 1; S2F, triplets associated with the quality attribute flavor of sample 2; S3F, triplets associated with the quality attribute flavor of sample 3; S4F, triplets associated with the quality attribute flavor of sample 4; S1X, triplets associated with the quality attribute texture of sample 1; S2X, triplets associated with the quality attribute texture of sample 2; S3X, triplets associated with the quality attribute texture of sample 3; S4X, triplets associated with the quality attribute texture of sample 4; S1T, triplets associated with the quality attribute taste of sample 1; S2T, triplets associated with the quality attribute taste of sample 2; S3T, triplets associated with the quality attribute taste of sample 3; S4T, triplets associated with the quality attribute taste of sample 4.

beverages samples as calculated in table 2 and triplets for relative weightage of quality attributes, as mentioned in Eq.3 were multiplied in order to find out triplets of overall sensory scores. Triplet values for overall sensory scores of all the samples can be represented as:

SO1= 84.090 25.000 11.363
SO2= 70.454 25.000 15.909
SO3= 65.909 25.000 15.909
SO4= 45.454 15.909 20.454

Overall membership functions of sensory scores on standard fuzzy scale

As discussed earlier, for the evaluation of sensory scores six-point sensory scale designated as F1, F2, F3, F4, F5 and F6 respectively, was used showing membership function values for the standard fuzzy scale in Eq. 4. By using Eq. 5 as discussed earlier Bx, designated as overall membership function of

Table 2. Sum of the number of judges with different preferences, triplets associated with scores and the relative weightage for quality attributes of the whey beverages' samples in general

Quality attributes	NI	SI	IM	HI	EI	Triplets for sensory scores				Triplets for relative weightage		
Color	0	0	2	3	6	QC	43.18	20.45	22.72	QCrel	0.316	0.094	0.042
Flavor	0	2	2	3	4	QF	47.72	22.72	22.72	QFrel	0.265	0.094	0.059
Texture	0	3	2	2	4	QX	47.72	20.45	25	QXrel	0.247	0.094	0.059
Taste	4	1	1	3	2	QT	65.90	25	20.45	QTrel	0.170	0.059	0.076
Color	0	0	2	3	6	QC	43.18	20.45	22.72	QCrel	0.316	0.094	0.042

EI, extremely important; HI, highly important; IM, important; NI, not at all important; QC, triplet for sensory score of quality attribute color; QF, triplet for sensory score of quality attribute flavor; QH, triplet for sensory score of quality attribute homogeneity; QT, triplet for sensory score of quality attribute taste; QCrel, triplet for relative weightage of quality attribute color; QFrel, triplet for relative weightage of quality attribute flavor; QHrel, triplet for relative weightage of quality attribute homogeneity; QTrel, triplet for relative weightage of quality attribute taste; SI, somewhat important.

Table 3. Values of overall membership function of the whey beverage samples

Overall membership function	Values									
B1	0	0.242	0.500	0.757	0.983	0.983	0.701	0.420	0.138	0
B2	0	0	0.129	0.329	0.529	0.729	0.928	0.928	0.823	0.550
B3	0	0	0	0.168	0.354	0.54	0.725	0.911	0.911	0.821
B4	0.050	0.307	0.564	0.821	0.916	0.916	0.642	0.369	0.095	0

sensory scores of the samples on standard fuzzy scale, were calculated

For example, for the triplets for overall sensory scores of sample 1 (SO1 = (84.090 25.000 11.363), i.e., a = 84.090, b = 25.000, c = 11.363 (Eq. 7), the value of Bx at x = (0 10 20 30 40 50 60 70 80 90 100) was found out as B1 = (0, 0.242, 0.500, 0.757, 0.983, 0.983, 0.701, 0.420, 0.138, 0). By using similar method overall membership functions of sample 2 (B2), sample 3 (B3) and sample 4 (B4) were also estimated (Table 4).

Similarity values of whey based beverages samples and their ranking

By using the values of membership functions of standard fuzzy scale and overall membership function values of sensory scores similarity values for the beverages were calculated. For calculating the similarity values eq. 6 was used as mentioned above. As example we can say about sample 1, for whose B1, F1*B1', F1*F1'and B1*B1 is membership function on standard fuzzy scale obtained by applying rules of multiplication. In eq. 6 denominator is replaced by maximum value among F1*F1' and B1*B' and numerator is replaced by the value of F1*B1. The similarity values calculated under F1 (Not satisfactory) was 0.0343. In the same way, similarity values under other categories viz. F2 (Fair), F3 (Satisfactory), F4 (Good), F5 (Very good) and F6 (Excellent) were also estimated. Table 5 shows the similarity values for all the four samples under different scale factors. From the table it can be observed that, the highest similarity value for sample 1 lied under the category of satisfactory whereas, for sample 2,3 and 4 the highest similarity was categorized as very good, very good and satisfactory respectively. As sample 2 and 3 lied under the same category, their ranking values were compared. It was observed that sample 3 had highest ranking value. So the ranking of all the samples were done as S3 (Very good) > S2 (Very good) > S1 (Satisfactory) > S4 (Satisfactory). From the ranking, it can be concluded that sample 3 (1 litre cheese + 0.70 gm stabilizer + 8% sugar + 1% orange powder + 0.40 ml

Table 4. Similarity values of the whey beverages and their ranking

Scale factors	Sample 1	Sample 2	Sample 3	Sample4
Non satisfactory	0.034	0.215	0.232	0.266
Fair	0.317	0.171	0.135	0.412
Satisfactory	0.706	0.277	0.184	0.572
Good	0.676	0.514	0.440	0.508
Very good	0.257	0.536	0.602	0.181
Excellent	0.019	0.207	0.296	0.011
Ranking	III	II	I	IV

Table 5. Similarity values and ranking of quality attributes of whey beverages

Scale Factors	Color	Flavor	Texture	Taste
Not at all necessary	0	0.2891	0.3492	0.3668
Somewhat necessary	0	0.1445	0.1746	0.3144
Necessary	0.0073	0.1366	0.2603	0.6743
Important	0.3564	0.6202	0.7266	0.534
Highly important	0.9178	0.5413	0.4327	0.053
Ranking	I	III	II	IV

flavor) was the most acceptable sample of beverage among all the samples. The sensory value increased with an addition of essence to the beverage mix and also addition of stabilizers in case of preparing a beverage sample made it a good sample (Modler *et al.*, 1983; Jaya and Das, 2004). Besides that addition of probiotic promote a positive impact in the host by improving the properties of the indigenous beneficial microbiota (Shukla *et al*. 2013). In this study, addition of probiotic and flavor in the whey beverages increased the sensory properties in terms of consumer acceptance. It was observed that sensory properties of the beverages increased upto a certain concentration of flavor. Sample 3 (Very good) due to its highest concentration of flavor showed highest acceptability. Sample 2 was also in the category of very good, but ranked lower than the sample 3 in terms overall quality attributes. Sample 1 and 4 was under the category of satisfactory. But sample 1 ranked as more satisfactory beverage than sample 4, which was a general whey beverage available in the market without the addition of probiotic. So from these results it can be observed that addition of probiotic and flavor in the whey beverages makes it a better acceptable beverage in terms of sensory properties.

Qualities ranking of whey beverage samples

In terms of popularity different quality attributes play important role for different types of food. So in case of whey beverages color, flavor, texture and taste were chosen as quality attributes. The ranking of quality attributes of the beverages in general was done in order to find out the most important factor followed by the estimation of similarity values under various scale factors. By using the same procedure as mentioned above the values of overall membership functions for sensory scores of the quality attributes viz. color (C), flavor (F), texture (X) and taste (T) were calculated. The numerators and denominators of eq. 6 were determined by using the values of C, F, X and T. All the quality attributes of whey beverages is shown in table 6. After comparing similarity values, it can be concluded that color (0.9178) is "highly important" in case of whey beverages and also can be considered as the most important factor amongst all. Both flavor and texture were found to be in the category of "important" but similarity value of flavor (0.7202) was found to be less than texture (0.6266). So the texture was considered to be the second most important factor and flavor as the third most important factor, deciding the acceptability of whey beverages. Among all the quality attributes, taste was ranked as "necessary" showing least importance than all. So, in general the order of preference of quality attributes for the beverages was illustrated as Color> Texture> Flavor> Taste. From these it can be concluded that due to the ranging of these factors from necessary to highly important, all quality attributes can be declared as important sensory parameter in general.

Conclusion

The major objective of the present study was to develop a value added and organoleptically acceptable whey beverage containing probiotic culture. The probiotic whey beverage fermented with probiotic culture was organoleptically evaluated to decide their acceptability in which average of three samples were analyzed for sensory evaluation by using fuzzy analysis. In this study, it was observed that, probiotic whey beverage was the best ranked beverage followed by S3, consisting of 1 litre cheese + 0.70 gm stabilizer + 8% sugar + 1% orange powder

+ 0.40 ml flavor; followed by S2 in second rank and S1 in third rank .Standard market whey beverage S4 was ranked the last. In general, Color > Flavor > Texture > Taste can be claimed as the rating for the important quality attributes of the whey beverages. In terms of the study at the preliminary level, this observation is useful so as to increase the prospect of using whey as beverage, which is not a popular practice yet. In conclusion, this study also revealed that by incorporation of orange flavor and sugar on fermenting with probiotic culture, it is possible to convert cheddar cheese whey into an organoleptically acceptable beverages followed by the improvement of sensory properties of the beverage in terms of consumer acceptance. As with the optimized concentration of orange flavor, the sensory properties of the probiotic whey beverages also improved, making sample third as the best beverage among all the available whey beverages with having highly therapeutic valuable thirst quenching beverage.

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