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DEVELOPMENT OF FLAVORED YOGURT FROM NON-DAIRY MILK AS A SUBSTITUTE TO FLAVORED DAIRY YOGURT

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Abstract- Currently, only dairy-based flavored yogurts are readily available in the Indian market. Lactose intolerant or vegan population cannot consume these dairy-based yogurts. Thus, plant-based milk yogurts can be a good substitute for these flavored dairy yogurts. A market survey demonstrated that flavored non-dairy yogurts are prevalent in the International market but not easily available in the Indian market. Moreover, these yogurts contain thickening agents to match their consistency like dairy yogurt. Hence the objective of this study was to develop a flavored yogurt from plant-based milk without the use of any additional thickening agents while maintaining consistency and acceptability like that of Dairy Yogurt. This yogurt would also act as functional food providing required nutrients and probiotics to vegan and lactose-intolerant populations. A variety of plant-based (non-dairy) milk was experimented to set yogurts using two different culture but the required consistency and flavor were achieved in Soya Yogurt and yogurt made from a mixture of Almond milk, Cashew milk and Brown Rice Milk using a mesophilic culture. Then various flavors of yogurts were developed which lead to successful five different flavored non-dairy yogurts.

Keywords – Non-dairy Yogurt, Lactic acid bacteria, Flavored Yogurt, Culture, Plant-based

I. INTRODUCTION

"Yogurt" is a fermented dairy product that is made using specific bacterial strains, typically Streptococcus thermophilus and Lactobacillus bulgaricus. It is considered as a source of several essential nutrients like protein, calcium, potassium, phosphorous, vitamin B2 and B12, etc. as well as a source of probiotics that offer a range of health benefits. [1], [10]

However, yogurt made from dairy-based milk has certain health risks associated with it for some people like lactose intolerance, high cholesterol content, allergy to milk proteins, etc. [7] as well as socially unacceptable to vegan people. Hence consumers are more looking for alternatives to dairy products and this is a growing trend. [9]

Yogurts developed from various kinds of plant-based milk serve as a safe substitute for lactose intolerant people as part of their diet as they are lactose-free [8] and may cater to consumers with dairy allergies or vegan [3].

Milk substitutes made from plant-based resources are water extracts of legumes, oilseeds, cereals or pseudocereals that resemble cow's milk in appearance. The most widely consumed plant milk substitute is soya milk, but emerging alternative products made from coconut, oat, almonds, etc. have decreased its share in the dairy alternative market. [2]

Yogurt is usually characterized as a smooth, viscous gel with a specific sharp acid taste and green apple flavor. [6], [11], [12] The primary attributes of yogurt for acceptability include color, flavor, and texture. [6]

Amongst these attributes, flavor plays an important role in determining acceptability and preference amongst the customers. [6] Currently, companies preparing non-dairy yogurts are experimenting and innovating by trying new

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bases like oats or hemp to trying unique flavors like mango cream or maple to position their product for growth. This segment caters to consumers with dairy allergies or vegan. [3]

Thus, the aim of this study was to develop unique flavored non-dairy yogurt as a substitute for flavored dairy yogurts with the use of as many natural ingredients as possible.

II. Materials and Methods

A. *Materials used:–*

1. Raw Food Materials used for the study are as below: -

- Soybean (loosely sold in grocery shop)
- Almonds (loosely sold in grocery shop)
- Cashews (loosely sold in grocery shop)
- Brown Rice (Daawat Brown Basmati Rice)
- Coconut (loosely sold in grocery shop)
- Oats (Quaker Rolled Oats)
- Peanut (loosely sold in grocery shop)
- White Rice (Kolam Rice loosely sold in a grocery shop)
- Mango Pulp (Frozen Home-made from Alphonso Mango)
- Blueberries (Loosely sold in fruit market)
- Pineapple (Loosely sold in fruit market)
- Cocoa powder (Cadbury Cocoa Powder Mix)
- Raspberry (Loosely sold in fruit market)
- Chaat Masala (Everest Chaat Masala)
- Cumin Powder (Everest Cumin Powder)
- Chili Powder (Everest Tikhalal Chili powder)
- Soya Masker (DDS-TPM)
- Pineapple Flavor (DDS-TPM)
- Natural food color – yellow (Roha Dye Chem – beta carotene)
- Mesophilic Culture (CHR Hansen – CHN -22 - containing following micro-organisms -Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. Lactis biovar diacetylactis, Lactococcus lactis subsp. Lactis, Leuconostoc mesenteroids, Leuconostoc pseudomesenteroides)
- Thermophilic Culture (CHR Hansen – Fd-dvs-YoFlex Express 1.0 consisting of following micro-organisms - Streptococcus thermophilus, Lactobacillus bulgaricus).

2. Preparation of Raw Materials

The Culture obtained from CHR Hansen is diluted in the following manner: -

1 gm in 50 ml sterile water and from that dilution add 2 ml solution in 1 liter of plant-based milk

B. *Method used: -*

Today, yogurt is prepared commercially by culturing milk with two strains of bacteria (S. thermophiles and L. bulgaricus) and keeping them in a sterile environment at very low temperature (36°C–42°C) for 3–8 hrs. Both the bacterial strains must remain active in the final product (with at least 10 million bacteria/g, according to CODEX

2003). The process which takes place before conversion into yogurt is responsible for changes caused in carbohydrates, proteins, and lipids. When sugar present in milk is used as a fermentation substrate, acid and other compounds are formed. This develops acidic flavor and a product with improved digestibility, appearance, taste and consistency. Due to low pH, the development of other undesirable microbes is delayed, proteins are now easily digested by proteolytic enzymes which enhances the digestibility of the product and the overall bioavailability. [1]

Apart from the above two mentioned culture species the other predominant organisms used in starter culture may also include Bifidobacterium species and Leuconostoc species. It is observed that during fermentation, these lactic acid bacteria perform three major biochemical changes in milk components: -i) Carbohydrates gets converted into lactic acid or other metabolites (glycolysis), (ii) hydrolysis of caseins into peptides and free amino acids (proteolysis) and (iii) milk fat breaks down into free fatty acids (lipolysis). All these reactions lead to the production of various flavors developed in the yogurt. [6]

Based on the above information we tried two cultures to set yogurts - Mesophilic Culture (CHR Hansen – CHN-22 - containing following micro-organisms - Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. Lactis biovar diacetylactis, Lactococcus lactis subsp. Lactis, Leuconostoc mesenteroids, Leuconostoc pseudomesenteroides) and Thermophilic Culture (CHR Hansen – Fd- dvs -YoFlex Express 1.0 consisting of following micro-organisms - Streptococcus thermophilus, Lactobacillus bulgaricus).

1. Preparation of plant-based milk: -

a) Single ingredient plant-based milk:

The plant-based material (Rolled Oats/ Almonds/Cashews/ Peanuts/Brown Rice/White Rice/Soya Beans) are cleaned to remove any extraneous matter, then washed with potable water and soaked in potable water for 6 hours. Then the soak water is drained off and the material is washed with clean potable water. Add water in the material in the ratio 1 part of the material: 3 parts of water and extract the milk out of the plant-based material by grinding it in a mixer grinder. Strain the mixture to obtain raw milk.

The extraction of coconut milk also uses the same procedure except the soaking part. It is directly grounded in a mixer along with 3 parts of water to extract coconut milk and then strained.

The plant-based milk (except soya milk) is then given a boil on medium heat flame and cooled to a temperature of 43 ^{o}C.

The soya milk is boiled at 100 ^{o}C for 20 mins and then cooled to 43 ^{o}C. This helps reduce the trypsin inhibitors and other anti-nutritional factors that may be present in soya milk, improve its digestibility as well as pasteurize the milk. [9], [13], [14]

b) Mixed Vegan Milk:

To prepare Mixed Vegan Milk, the single ingredients are taken in the below mentioned proportions. The single ingredient plant-based milk is then prepared as per the above-mentioned procedure and before boiling, the single ingredient milks are mixed.

Cashew milk + Almond milk+ Brown Rice milk = 1 part Cashews :1 part Almonds: 4 parts Brown Rice

Cashew milk + Almond milk+ Brown Rice milk+ Peanut milk = 1 part Cashews: 1 part Almonds: 4 parts Brown Rice:1 part peanuts

Cashew milk + Almond milk+ Brown Rice milk+ Soyabean milk= 1 part Cashews: 1 part Almonds: 4 parts Brown rice: 1 part Soya

2. Inoculation: -

The milk is then inoculated with the culture, covered and allowed to stand undisturbed at 34 ^{o}C for 8 hours. Post that it is refrigerated below 5 ^{o}C until used.

3. Preparation of Flavored Yogurt: -

Mango, Blueberry, Raspberry and Pineapple Yogurt is prepared by mixing yogurt (Soya yogurt or mixed plant milk yogurt) with fruit pulp and sugar in the ratio 5 parts yogurt:2 parts fruit pulp:1 part of sugar. Soya masker is

added in Soya yogurt in 0.06% w/w. Curcumin Color (0.06% w/w) and pineapple flavor (0.06% w/w) are added only in the case of pineapple-flavored yogurt.

In the case of chocolate-flavored yogurt, yogurt is mixed sugar in the ratio of (5 parts yogurt: 1 parts sugar) and 1.5 % w/w of cocoa powder is added to this mixture. Soya masker (0.06% w/w) is added if soya yogurt is used.

Chaat flavoured yogurt is made by mixing yogurt with 1% chaat masala powder, 1% chilli powder, 1% cumin powder and 1% black pepper powder.

III. Experiment and Result

TRIAL 1

Objective: To set plain yogurt using different kinds of milk (Single Ingredient Milk) to a consistency like milk yogurt and check the sensory acceptance of all.

Seven kinds of plant-based milk used were inoculated using Mesophilic culture (from CHR Hansen) and incubated at 34 ^{o}C

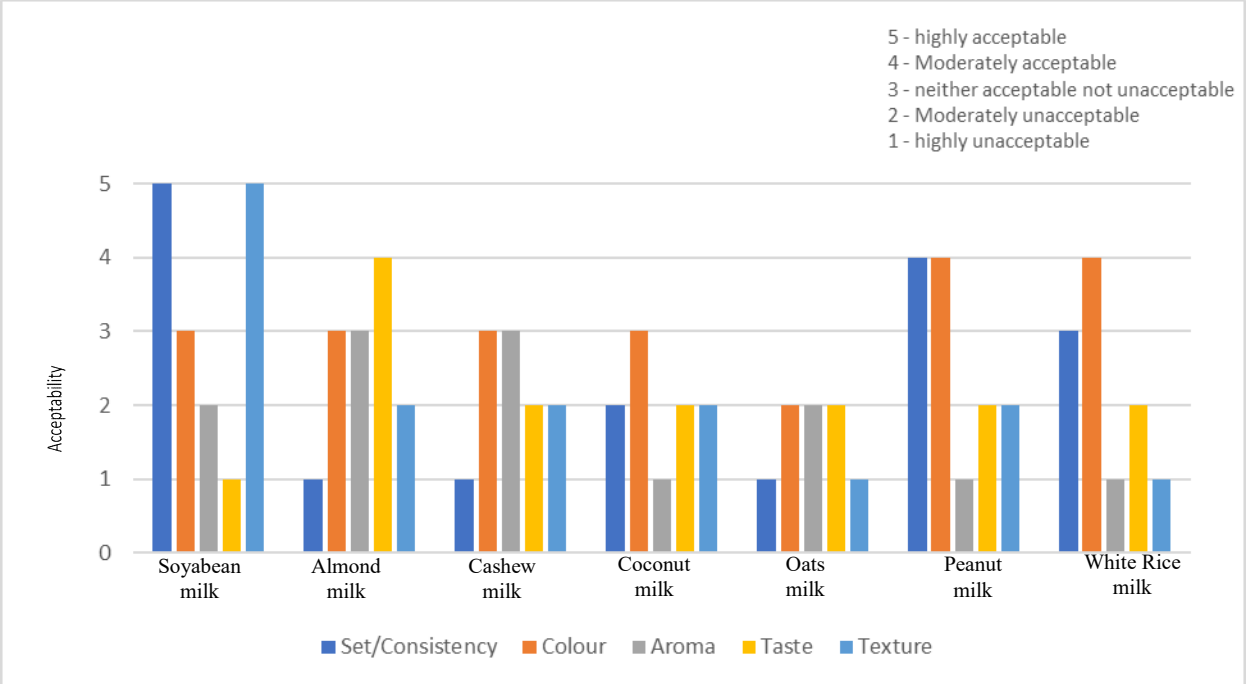

Figure 1. Acceptability of various plant-based yogurts with respect to sensory parameters compared to that of plain dairy yogurt when prepared using mesophilic culture

INFERENCE: From the above graphical representation, it is clear that yogurts made from Soyabean, Peanut milk were found acceptable with respect to Set/Consistency closest to that of dairy yogurt but unacceptable in terms of taste as they had a peculiar beany taste. Yogurt made from Almond milk was found acceptable with respect to taste due to nutty flavor it imparted to the yogurt but did not have an acceptable Set/Consistency.

TRIAL 2

Objective: - Since in Figure 1 it was observed that yogurt made from almond milk gave good taste but not a good set. Hence the objective was to increase the consistency of the yogurt by combining plant-based milk which gave a good set. Also, Cashew and Brown Rice were used with an aim to increase the thickness of the yogurt without using any artificial thickeners as starch is a major carbohydrate present in Brown Rice and Cashews. [4], [5]

The following three combinations of vegan yogurts were prepared and tested for acceptability

- Cashew milk + Almond milk+ Brown Rice milk
- Cashew milk + Almond milk+ Brown Rice milk+ Peanut Milk
- Cashew milk + Almond milk+ Brown Rice milk+ Soyabean milk

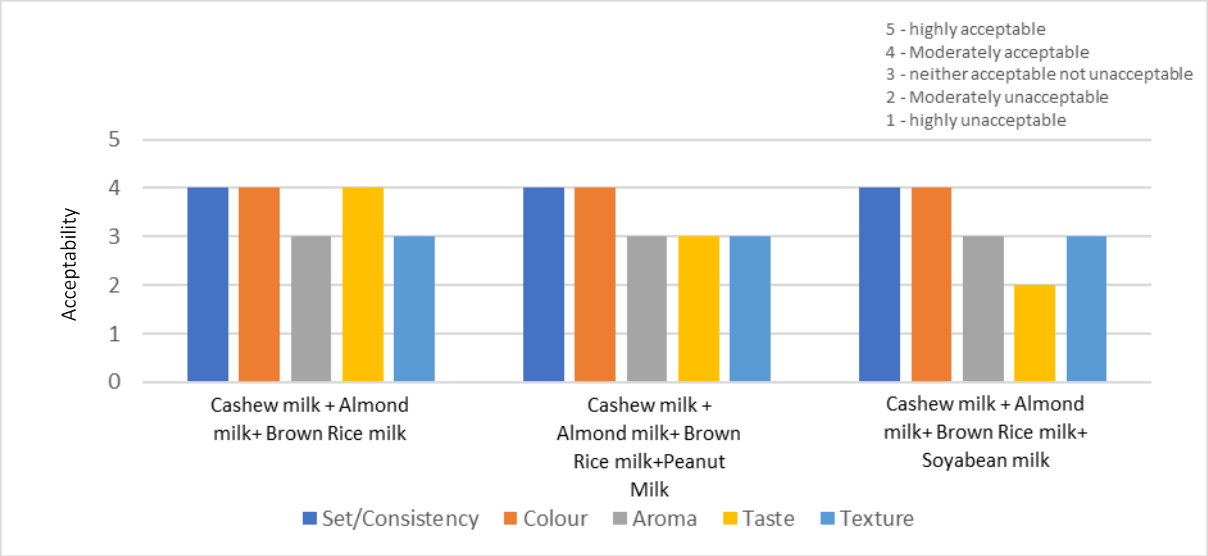

Figure 2. Acceptability of yogurts prepared from various mixed plant-based milk with respect to sensory parameters when compared to plain dairy yogurt when prepared using mesophilic culture

INFERENCE: Out of the three combinations tried, a combination of Almond milk, Cashew Milk and Brown Rice Milk comparatively gave yogurt with good texture and taste hence this combination was finalized for the further development of flavored yogurts.

TRIAL 3

Since raw peanuts gave beany taste, milk extracted from roasted peanuts was tried to make yogurt

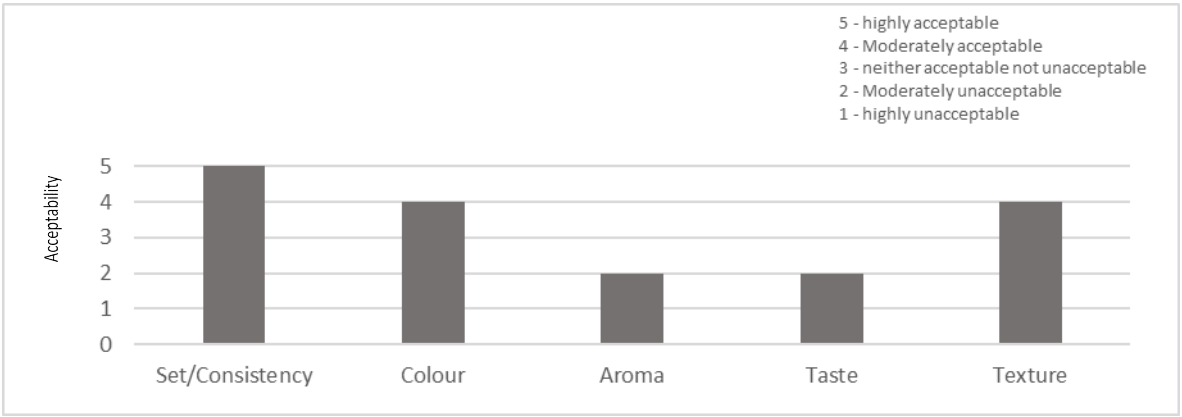

Figure 3. Acceptability of yogurts prepared from roasted peanut milk when compared to dairy yogurt.

INFERENCE: - There was no significant difference in taste nor Set/Consistency in yogurt prepared from roasted peanut milk compared to unroasted peanut milk. Since the yogurt had a peculiar peanut flavor which was not acceptable, this ingredient was not further used.

TRIAL 4

Objective: - As thermophilic culture is generally used for making dairy yogurts, we experimented to prepare yogurt from the same ingredients as TRIAL 1 and TRIAL 2 using thermophilic culture and incubated at 40 °C

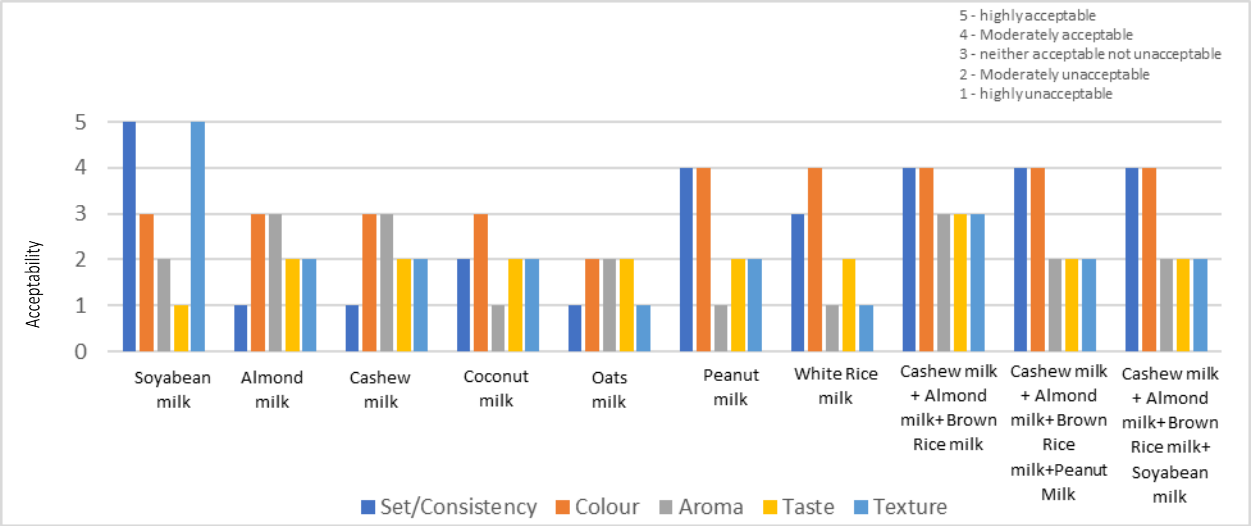

Figure 4. Acceptability of yogurts prepared from various plant-based milks using thermophilic culture.

INFERENCE: The results obtained were almost similar to the mesophilic culture. However, the mesophilic culture gave better taste in almond milk and mixed plant-based milks.

TRIAL 5

Objective: -
The two yogurts which were finalized for product standardization were: -

1. Soya Milk Yogurt

2. Mixed Vegan Yogurt using milk extracted from Almond + Cashew + Brown Rice (Ratio 1:1:4)

Now the objective was to prepare flavored yogurts from the prepared yogurts. This was done by mixing the prepared yogurt with other ingredients like fruit pulps (in case of fruit yogurt), cocoa powder (in case of chocolate yogurt), spices or sugar, etc. depending on the flavored yogurt that is intended to be prepared.

Since the peculiar beany flavor of soyabean was evident in the yogurt despite boiling it, soya flavor masker (from DDS-TPM) was used to mask the beany flavor. Since the color and flavor in pineapple yogurt was very faint, additional color (natural color – curcumin from Roha Dye Chem) and flavor (pineapple flavor from DDS-TPM) were added.

Base Yogurt used	Flavor	Sensory Evaluation					Acceptability
		Set/Consistency	Color	Aroma	Taste	Texture	
1.	Mango	Loose	Yellow	Mango	Sweet Mango	Smooth	Acceptable
1.	Chocolate	Loose	Brown	Cocoa	Sweet chocolaty	Smooth	Acceptable
1.	Blueberry	Loose	Violet	Berry like	Mild tangy	Smooth	Acceptable
1.	Raspberry	Loose	Pink	Mild Raspberry	Sweet tangy	Gritty	Unacceptable texture of grittiness of raspberry seeds
1.	Chaat	Loose	Light orange	Mild spicy	Salty and spicy	Smooth	Acceptable
1.	Pineapple	Loose	Yellow	Fruity	Sweet	Smooth	Acceptable

Figure 5. Sensory Evaluation of the various flavored yogurts prepared using Soya Milk Yogurt.

Base milk used	Flavor	Sensory Evaluation					Acceptability
		Set/Consistency	Color	Aroma	Taste	Texture	
2.	Mango	Thick	Yellow	Mango	Sweet Mango	Smooth	Acceptable
2.	Chocolate	Thick	Brown	Cocoa	Sweet chocolaty	Smooth	Acceptable
2.	Blueberry	Thick	Violet	Berry like	Mild tangy	Smooth	Acceptable
2.	Raspberry	Thick	Pink	Mild Raspberry	Sweet tangy	Gritty	Unacceptable texture of grittiness of raspberry seeds
2.	Chaat	Thick	Light orange	Mild spicy	Salty and spicy	Smooth	Acceptable
2.	Pineapple	Thick	Yellow	Fruity	Sweet	Smooth	Acceptable

Figure 6. Sensory Evaluation of the various flavored yogurts prepared from yogurt made of a combination of Almond Milk, Cashew Milk and Brown Rice Milk

INFERENCE: All the flavors in both the yogurt bases were found to be acceptable except the raspberry flavor because of gritty texture imparted by raspberry seeds.

Analysis of flavored yogurt: -

The pH was measured with a digital pH-meter at 20 ^{o}C. The pH was determined by inserting the pH probe directly into a homogenized sample. The following results were obtained.

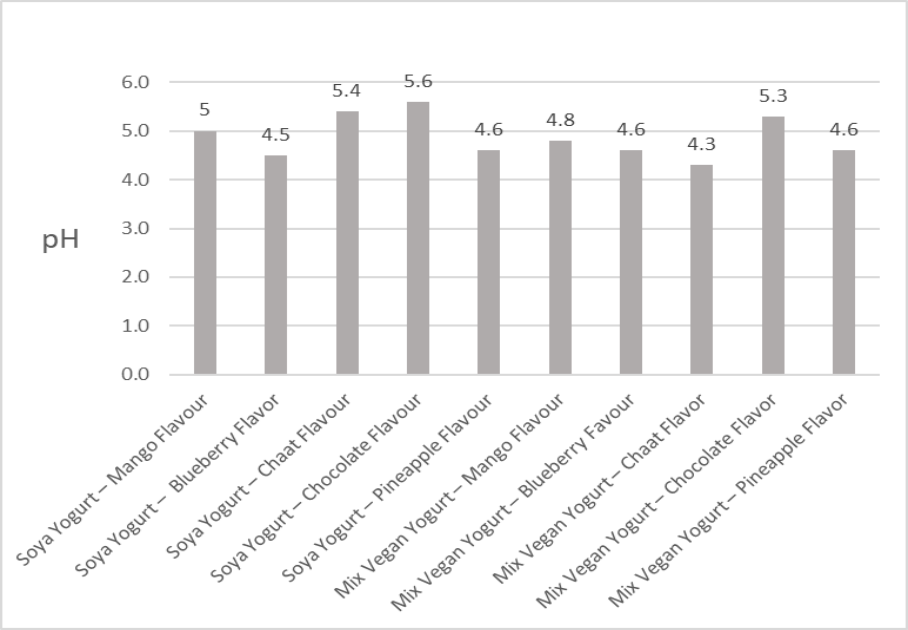

Figure 7. pH of various flavored yogurts

Sensory Evaluation of the yogurt using hedonic ranking scale: -

Mango Flavored Soya yogurt was taken as a sample. The sensory analysis of this yogurt sample was conducted by 15 trained panelists aged between 20-40 years using hedonic preference test. This test gives several indications of how much a product is liked. Based on the assumption that consumers will only buy a product if they enjoy eating it, the panelists were asked to rate the product for each sensorial characteristic on a scale of 0-9, where 0 stands for dislike extremely and 9 stands for like extremely. The average of all the responses was calculated and the below results were obtained. The average of every parameter was between 5 to 7. The average overall liking of the product was around 6.7 which meant that it was moderately liked by the panelists. This is considered as a positive response in terms of the liking of the product.

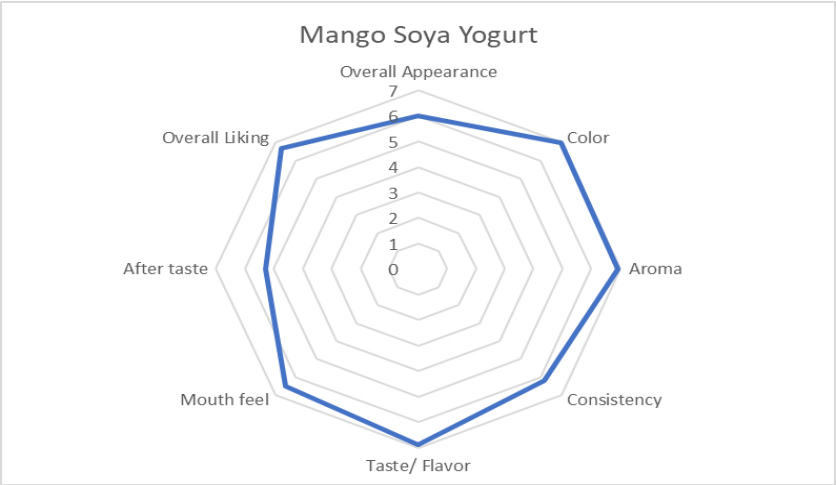

Figure 8. Hedonic Test Rating for Mango Flavored Soya Yogurt

V.CONCLUSION

The market for non-dairy based products as a dairy alternative is increasing. With the increasing demand for dairy alternatives, our aim of the study to develop flavored non-dairy yogurt as a substitute to flavored dairy yogurt was achieved with the development of five flavors each in two different non-dairy yogurts – Soya yogurt and Mixed Vegan Yogurt (Almond + Cashew + Brown Rice). Also, since increasing consumer awareness is leading them to look out for more natural products, the objective of preparing a yogurt without the use of any thickeners was achieved by mixing the properties of 2-3 ingredients to prepare a flavored yogurt which was not only acceptable in taste but also healthy. Almond, which is a good source of protein, that is important for coagulation during yogurt preparation was mixed along with Brown Rice and Cashews which are a good source of starch, which acts as a natural thickening agent. The unwanted organoleptic characteristics of these yogurts are masked off using natural fruits pulps or spices to prepare flavored yogurts. In the case of soya yogurt, soya flavor masker helped in masking off the beany flavor.

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