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ORIGINAL ARTICLE

Understanding consumer preferences to develop dahi using pineapple pomace powder and monk-fruit extract

Sparsh Gumber[1] · Shiv Kumar[1] · Rekha Kaushik[1] · Harish Kumar[2] · Rahul Mehra[1]

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Abstract Consumer preferences refer to the subjective assessments of products and services expressed by individuals. The objective of this investigation aims to examine the preferences of consumers regarding dahi, followed by the development of a corresponding product. The initial phase of the experimental design involves understanding the interests of consumers and the variables that influence their purchasing intentions through the administration of a questionnaire. The subsequent phase entails the development of dahi in accordance with consumer preferences, followed by an assessment of its nutritional value, sensory acceptability, and storage study. Subsequently, a significant proportion of consumers (91%) expressed an interest for the introduction of a pineapple-flavour (61.5%) spoon-able dahi (77%) containing natural sugar (65%) and packaged in a cup (71.5%) within the market. To adjust the sweetness intensity of monk fruit, a series of preliminary experiments were carried out to regulate the concentration to a level that can be considered sensory acceptable, specifically 05 g/100 ml. Afterwards, dahi was prepared by altering the concentration of FPP (freeze-dried pine-apple pomace powder) within the range of 0.5 to 2.5 g/100 ml. Prepared dahi were further subjected to sensory evaluation and storage study. Based on the obtained results and sensory analyst feedback, we conclude that the dahi formulation TPM2 exhibits considerable organoleptic acceptance and also has the potential for industrial-scale production to cater wider consumer demands.

Keywords Dahi · Consumer preference · Pine-apple pomace powder · Monk fruit

Abbreviations

PPP Pine-apple pomace powder
MFE Monk fruit extract
PCA Principal Component Analysis

Introduction

Consumers' food preferences can be characterized as a combination of subjective tastes, necessity, and various influencing factors that motivate them to purchase a product, which is subsequently evaluated based on the satisfaction or utility derived from the item (Vandevijvere et al. 2020; Saulais et al. 2023). Furthermore, Grunert and Wills (2007) define, food preferences are conceptualized in relation to our pre- and post-purchase quality expectations of a food item. The physiological requirement for sustenance is a fundamental need that possesses a straightforward objective and appears to have a clear-cut resolution for satiation (Vabø and Hansen 2014). The selection of food items is a multifaceted occurrence that entails a variety of factors, including both sensory and non-sensory characteristics. The non-sensory attributes encompass factors such as accessibility, cost, convenience, and brand, among others. The aforementioned factors collectively contribute to the decision-making process entailed in selecting food (Forde and De Graaf 2022).

Consumer preference is important aspect that must be taken into consideration during the design, formulation, and development of a product. This not only ensures the creation

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✉ Rahul Mehra
rahulmehranov@gmail.com

1 Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India

2 Shri Vishwakarma Skill University, Palwal, Haryana, India

of a safe and innovative product but also provides an opportunity for future investigation. By understanding the preferences of consumers, manufacturers can tailor their products to meet the demands of the market and offer a unique value proposition. Therefore, it is imperative to conduct thorough research on consumer preferences to ensure the success of a product in the market (Khan and Pandey 2023). Świąder and Marczewska (2021), stated that while creating a recipe for a novel product may not be a challenging task, crafting a product that satisfies the anticipated consumer demand and generates profitable sales can prove to be an enormous undertaking.

The escalation of life expectancy and alterations in lifestyle and dietary patterns have been concomitant with a surge in the incidence of various chronic ailments such as osteoporosis, cancer, cardiovascular diseases, hypertension, and diabetes, among others (Li et al. 2020). Over the past few years, there has been an increasing preference among consumers to give precedence to their health and overall well-being. Consequently, there has been a surge in the market demand for food items that are derived from natural sources and provide supplementary health advantages beyond fundamental nourishment (Temple 2022). Functional foods are emerging as a potentially viable option for disease prevention and cost reduction in healthcare. The objective behind the creation of such food products is to offer uncomplicated remedies to intricate health concerns (Alongi and Anese 2021). The functional foods industry has witnessed a substantial increase in its global market, primarily driven by a growing emphasis on the creation of innovative, naturally-derived products. The aforementioned trend reflects a persistent endeavour to enhance the composition of functional foods and broaden their accessibility to the general public (Galanakis 2021). The existence of a diverse range of choices for consumers mandates that manufacturers create products that align with the preferences and needs of the demographic they are targeting.

Dahi is a dairy product that is produced through the process of milk fermentation using lactic acid bacteria. It has been recognized for its ability to supply essential nutrients from milk to the human body (Khedkar et al. 2016). The process of fermenting milk serves to increase the bioavailability and bioaccessibility of the nutrients contained within dahi, thereby rendering it a distinctive and advantageous food asset (Mehra et al. 2022). This product resembles yoghurt in appearance, which occupies a prominent place in the diet or as a refreshing beverage of a large section of the Indian subcontinent (Goyal et al. 2016). Dahi, used to make lassi, shrikhand, and other sweets and drinks, accounts for 8% of India's milk production (Khedkar et al. 2016). Dahi is a rich source of essential nutrients that are easily digestible, thereby promoting gastrointestinal health, lower hypocholesterolemia levels, management of dysentery, constipation, and diarrhea (Balamurugan et al. 2014; Khedkar et al. 2016; Kumar and Durgawati 2021). Apart from this "dahi" also have spiritual values known as "Panchamrita" (Mudgal and Prajapati 2017).

Enrichment of dairy products with natural ingredients containing bioactive ingredients will help in overcoming these deficiencies and make milk products wholesome food (Zahedirad et al. 2019). *Ananas comosus*, commonly known as pineapple, belongs to the Bromeliaceae family and is extensively utilised in different forms including fresh, processed into ready-to-serve beverages, crushes, and jams (Wali 2019, Meena et al. 2022b), reported that the production of pineapple juice generates a considerable amount of solid waste, which accounts for 50–60% of the fruit's weight. This waste comprises peel (30%), pomace (50%), crown (13%), and core (7%) and the disposal of this waste poses environmental and legal challenges. The by-products generated during processing contain significant amounts of nutritional and bioactive components, such as polyphenols, fibres, pigments, essential oils, and other beneficial constituents. These components possess various chemotherapeutic properties and can be utilized in industrial applications (Mohd Ali et al. 2020). However, the concentration and availability of these nutrients are significantly dependent on the drying process. Sah et al. (2016) reported that freeze-drying techniques have several advantages over conventional drying techniques in terms of minimal loss of bioactive constituents, solubility and other functional properties.

Sweetness, one of the most desired flavours, comes from sucrose and the overconsumption of sugar has been recognized as a leading factor in the onset of diabetes mellitus, dental caries, and hypertriglyceridemia (Buchilina and Aryana 2021). Currently, there is a growing consumer preoccupation with personal health and a corresponding desire to procure food items that are composed of low-calorie natural sweeteners. The extract derived from Monk fruit, also known as Luo Han Guo (*Siraitia grosvenorii*), exhibits promise as a viable alternative to artificial sweeteners like saccharin, acesulfame-K, and sucralose (Ban et al. 2020b). Moreover, monk fruit sweetener is a non-nutritive sweetener that possesses zero caloric value and displays a sweetness intensity ranging from 100 to 250 times that of sucrose (Buchilina and Aryana 2021). It is purported that the sweetness of Monk fruit is attributed to the existence of triterpenoid glycosides (Ban et al. 2020b). In addition to its sweet taste, monk fruit has been found to have various therapeutic properties, including antitussive, glucose-lowering, anticarcinogenic, and immunoregulatory effects, some authors also reported that the consumption of monk fruit extract is safe for individuals suffering from type 2 diabetes (Ban et al. 2020a; Buchilina and Aryana 2021).

The efficient management of waste generated by fruit and vegetable processing businesses is an increasingly significant global issue (Banerjee et al. 2018). Adopting underutilized food items and utilizing by-products and waste from fruits is a sustainable method for waste management and also provides the opportunity to develop innovative products that offer distinct sensory experiences. The components PPP and MFE, added to "Dahi," are frequently underutilized yet nonetheless provide numerous techno-functional qualities and health advantages.

The sweetness of monk fruit extract is due to its high content of mogrosides, which have approximately 250 times the sweetness of sucrose and are significantly sweeter than sugar but contain no calories (Yeung 2023). According to the Food and Drug Administration (FDA), mogroside is generally regarded as safe (GRAS). Because mogrosides are not recognized by the human body as carbohydrates or sugars, they do not cause an insulin response, making them a safe and ideal alternative for persons with diabetes or those who need to manage their blood sugar levels. Similarly, the fiber content in pineapple pomace can decrease sugar absorption in the bloodstream, thereby aiding with blood sugar regulation. This can be advantageous for people who have diabetes or are at risk of developing it (Banerjee et al. 2018).

The PPP possesses the ability to integrate the delectable and refreshing taste and aroma of pineapples into food items, rendering it a vital component for augmenting flavors. Pineapple pomace has inherent sugars that can impart a mild sweetness, rendering it a promising choice as a natural sweetening agent for food and beverages. The monk fruit sweetener shows promise as a natural sugar substitute for producing low-calorie functional foods and sugar-free products for obese and diabetic patients (Massoud and Hashem 2023). Furthermore, it does not promote tooth decay or cavities due to its absence of sugars that can negatively impact dental health. The PPP has potential benefits for weight management due to its high fiber content. The fiber in pineapple pomace can induce a sense of satiety, potentially assisting in weight management by reducing excessive overeating and snacking (Selani et al. 2014; Jose et al. 2022).

MFE mogrosides may have anti-hyperglycemic and anti-hyperlipidemic actions in rats with type 2 diabetes, as well as modulate insulin production by elevating glucagon-like peptide-1 (GLP-1) levels (Zhang et al. 2020). Furthermore, monk fruit extract possesses substantial antioxidative activities that have the ability to inhibit oxidative stress-mediated diabetes (Song et al. 2007). MME extract administration boosted glycogen levels in the liver and muscle without affecting serum urea nitrogen levels (Pandey and Chauhan 2019). Pineapple pomace contains a variety of bioactive active compounds, including polyphenols and anti-inflammatory compounds, that can help protect your cells from oxidative stress, lower cholesterol levels and the risk of cardiovascular disease, and inflammation (Angulo-López et al. 2021).

The PPP is an abundant source of dietary fiber, which plays a crucial role in promoting digestive health by regulating bowel motions, preventing constipation, and supporting overall gut health. In addition to this, fibers also possess several techno-functional qualities, such as water–oil holding capacity, stabilization of high-fat food items and emulsions, modification of viscosity and texture, and prevention of syneresis (Selani et al. 2014). Both PPP and MFE are versatile and lucrative ingredients that may be utilized in various ways within the food industry. Their incorporation enhances the technological functionality and nutritional attributes of food products, aligning with the principles of the circular economy.

Since the emergence of dahi in the market, its production has remained consistent in terms of both methodology and ingredients. Limited efforts have been made to enhance the popularity of dahi, resulting in constrained market value and limited consumer acceptance. Therefore, the present study endeavors to introduce an alternate variant of "dahi" that aligns with the discerning tastes of consumers, while simultaneously providing an intensified sensory experience with several health benefits. This was achieved through the formulation of dahi, utilizing natural ingredients such as pineapple pomace powder, which serves as a flavor enhancer, and monk fruit extract, a natural sweetener.

Material and Methods

The present study was conducted in three phases; (**a**) Accessing consumer preference, (**b**) Product formulation, and physicochemical analysis and (**c**) Sensory acceptability and storage stability of the prepared product.

Consumer Preference

An online survey has been conducted on 200 volunteers, divided into two age groups (62% Male and 38% Female): 18–25 and 26–50 years, in order to gain insight into consumer preferences and market value pertaining to dahi **(S_1)**. The descriptive-type questionnaire comprises 13 questions, as delineated in (Table S1). Before filling out the questionnaire, a brief introduction was given to the panelists to understand the study's objective. Afterwards, written consent was taken from those consumers for their participation before filling out the questionnaire. The average value of each question response was recorded to formulate dahi predicated on consumer predilection.

Raw materials

The fresh cow milk was procured from the local farm of Mullana, Haryana, India. Pineapple pulp pomace was taken from a juice vendor, followed by dehydration with lyophilizer (Free Zone, Labconco, USA) to obtain freeze-dried pineapple powder (PPP). The PPP was sieved by using a sieve having a mesh size of 60, and obtained powder was sealed in polypropylene and stored at 7 ± 1 ℃. The composition of freeze-dried pomace powder was; moisture 3.56 ± 0.09 g/100 g, ash content 2.49 ± 0.12 g/100 g, crude protein 2.86 ± 0.18 g/100 g, total dietary fibres 40.21 ± 0.16 g/100 g, titrable acidity 6.12 ± 0.21%, and water solubility index 43.33 ± 0.16%. The monk fruit concentrate of Urban Platter was purchased from an E-commerce site. The DVS-mixed culture of *lactococci* species and *streptococci* species was provided by ABsource Biologics, Pune, India.

Experimental design

The utilization of pineapple pomace powder (PPP) for its flavor and monk fruit concentrate as a sweetening agent is predicated upon consumer preference. The pineapple pomace is preferred over other derivatives of pineapple owing to its abundance of bioactive constituents in a concentrated, low-volume form that is readily available all year long, and its waste utilization approach. In the process of dahi preparation, several preliminary trials were conducted to adjust the concentration of monk fruit concentrate to a sensory acceptable level i.e., 0.5 g/100 ml. Using Pearson's Square, the fresh cow's milk was standardized with skim milk powder (SMP-Farmer Fresh, Alpha Milk Foods Pvt Ltd, India) to achieve an SNF of approximately 8.5%. The standardized milk was subsequently homogenized at 6000 rpm for 5–10 min using a lab homogenizer (Remi-RQ-127, India). Dahi was subsequently formulated by varying the FPP

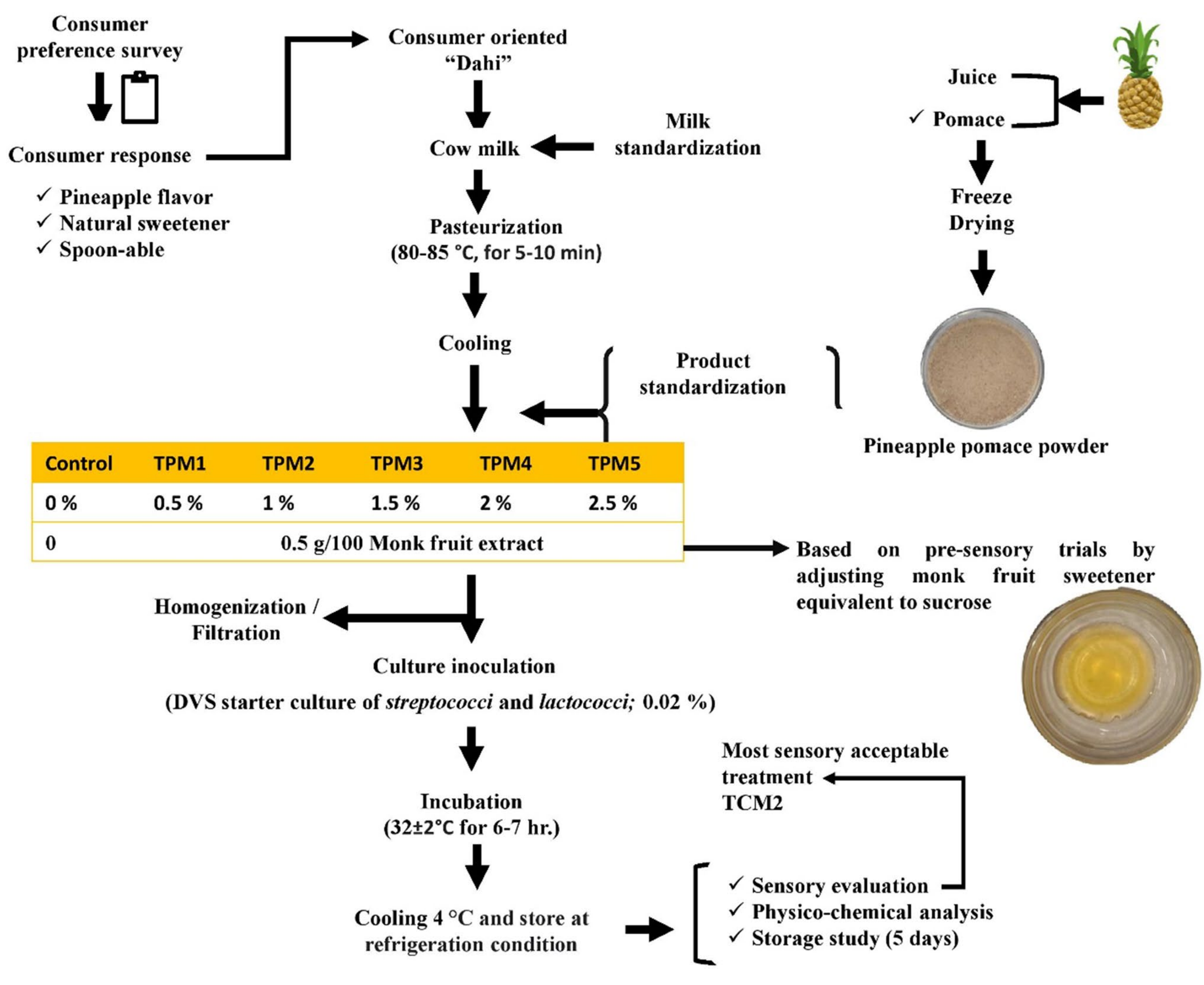

Fig. 1 Process optimized for the preparation of consumer-oriented "dahi"

concentration from 0.5 to 2.5 g/100 ml and inoculating a 0.02% DVS starter culture of *streptococci* and *lactococci* species. The incubation is done at 32 ± 2 °C for 6–7 h. till pH of 4.6 ± 0.5 is achieved. An overview of the process for making consumer-oriented dahi is illustrated in Fig. 1.

Physicochemical analysis

Prepared dahi samples were analyzed for different physicochemical parameters; ash, lactose, titrable acidity (% lactic acid) and total solids were estimated by following (AOAC 2005). The fat content was estimated by Gerber Method by following IS 1224–2 (Indian Standard 1977), and the protein content was estimated by using the macro-Kjeldahl method, by following (AOAC 2000). An automated Moisture analyzer (Mettler Toledo, Switzerland) was used to evaluate the moisture content of samples. A pH meter (Thermo Fisher Scientific, India) was used to determine the pH of dahi treatments. The syneresis of Dahi samples was estimated by the centrifugation method described by (Flores-Mancha et al. 2021). The carbohydrate content was calculated by the difference in the composition, and energy values were estimated by Equation I. The colour profile of all dahi treatments in terms of (L^*, a^* and b^*) was analysed by using ColorFlex EZ Spectrophotometer, Virginia, where the value of C^*, H_{ab} *and* TCD (ΔE^*) was calculated by following Eqs. 2, 3 and 4 respectively.

$$\textbf{Energy}(\textbf{Kcal}) = 4x\left[\text{ProteinandCarbohydrates(g)}\right] + 9x\text{Fat(g)} \quad (1)$$

$$\textbf{Chroma}(\boldsymbol{C^*}) = [(a^*)^2 + (b^*)^2]^{\frac{1}{2}} \quad (2)$$

$$\boldsymbol{H_{ab}} = tan^{-1}\left[b^*/a^*\right] \quad (3)$$

$$\textbf{TCD}\left(\Delta \boldsymbol{E}^*\right) = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} \quad (4)$$

Sensory evaluation

The evaluation of organoleptic acceptability and consumer purchase intention towards different pineapple-flavored dahi treatments were conducted through the implementation of a 9-point hedonic rating scale. The sensory panel comprises a total of 31 ($n = 17$ Female and $n = 14$ Male) individuals, including 6 faculty members, 2 chef's, 2 research scholars, and 21 semi-trained master's students from Maharishi Markandeshwar (deemed to be) University, Mullana, Ambala. All of the panelists were healthy and provided their informed consent regarding the regular consumption of dahi and also reported no history of allergies or intolerance to the ingredients listed. Prior to the final sensory evaluation, a preparatory and preliminary sensory assessment was conducted on commercially available dahi and flavored yoghurt, to familiarize the panelists with flavored yoghurt/dahi for understanding the study's objective. In the context of sensory analysis, coded dahi samples that were freshly prepared were presented to sensory participants under natural light conditions along with brine solution. The panelists evaluated each attribute (colour, appearance, consistency, taste, monk fruit flavor, pineapple flavor, aftertaste, homogeneity, texture, sweetness, buy the product, not-buy, and overall acceptability) and the resulting total mean values were subsequently recorded.

Statistical analysis

All the observations were recorded in triplicates and presented as Mean ± SD. The statistical difference was obtained through analysis of variance at the level of ($p \leq 0.05$). The Principal Component Analysis (PCA) was done using Origin-2023b (Northampton, United States).

Result and discussion

Consumer preference

An online survey was conducted on ($n = 200$; 61.5% Male and 38% Female) participants, of different ages 18–25 (60%), and 26–50 (40%). Out of participants ($n = 200$), 91% prefer dahi and 9% claimed they don't. Furthermore, two questions were added to the questionnaire to access what factors permute and demote the consumption of dahi, as well their frequency of the consumption of dahi. The data acquired from a consumer preference questionnaire indicates that taste (43%) and health benefits (34.5%) are the primary motivating factors for the consumption of dahi. Where, out of 9%, a total of 61.1% of individuals claimed that they don't like the taste of dahi as presented in Table 1.

In another set of questions, the consumption frequency, and purchase intentions were accessed, based on consumer preference, 40.5% of panelists claimed that they consumed dahi 3–4 times a week, where the health benefits owing from the product (25.5%) followed by taste (24%) are most contributing factor that significantly motivates consumers to buy dahi, where the price and quantity was least as presented in Table 1. In the final phase of surveys, an endeavor was made to ascertain the preferences and preferences of consumers, to develop a product that is tailored to their needs. Subsequently, a significant proportion of consumers (91%) expressed an interest for the introduction of a

Table 1 Consumer preference and response towards dahi

Sr. no	Question	Percentage (%)
1	**What is your age?**	
	a. 18–25	60
	b. 26–50	40
2	**What is your gender?**	
	a. Male	61.5
	b. Female	38
3	**Do you prefer dahi?**	
	a. Yes	91
	b. No	9
4	**If yes, why do you like dahi?**	
	a. Taste	43
	b. Health benefits	34.5
	c. Digestibility	21.5
	d. Other	1
5	**If no, why don't you like dahi?**	
	a. Don't like taste	61.11
	b. Price concern	11.10
	c. Don't find it necessary	11
	d. Lactose intolerance	5.5
	e. Other	11.2
6	**How frequently do you consume dahi?**	
	a. Daily	32
	b. 3–4 times a week	40.5
	c. once a week	17
	d. once in two weeks	3.5
	e. once a month	3.5
	f. Never	3.5
7	**Please indicate how important each of this feature is to you when you purchase dahi?**	
	a. Taste	24
	b. Health benefits	25.5
	c. Nutrition	20.5
	d. Flavor	18
	e. Price	6
	f. Quantity	6
8	**Do you prefer flavored dahi?**	
	a. Yes	80
	b. No	20
9	**If yes, what flavor would you like to eat?**	
	a. Beetroot	12
	b. Pineapple	61.5
	c. Pomegranate	11
	d. Mango	15.5
10	**Do you like sugar in dahi?**	
	a. Yes	84.5
	b. No	15.5
11	**If yes, which sweetener do you preferred?**	
	a. Natural	65
	b. Artificial	11.5
	c. Neutral	23.5
12	**Which kind of dahi do you prefer most?**	
	a. Drinkable [smoothies]	14.5
	b. Spoon able	77
	c. Rehydrated	2
	d. Neutral	6.5
13	**What do you prefer to have your dahi with/ in?**	
	a. Cup	71.5
	b. Pouch	8
	c. Other	20.5

pineapple-flavoured (61.5%) spoon-able dahi (77%) containing natural sugar (65%) packed in cup (71.5%) into the market Table 1**.**

Physico-chemical analysis

The physicochemical composition of dahi is subject to significant variation due to internal and external factors such as raw materials, and processing techniques. As a result, it is challenging to establish a direct correlation between this study and other reported investigations. An effort is being made to establish a correlation between the study being presented and a comparable product, such as yoghurt. Table 2 presents an analysis of various physicochemical parameters of prepared dahi. During the estimation of proximate composition, a statistically significant difference ($p \leq 0.05$) was noted in all parameters, except fat and lactose. The incorporation of PPP at a concentration of 1 g was observed to cause a slight decrease in pH values in dahi treatments. The maximum titratable acidity of 1.13 ± 0.08% was observed in dahi prepared with 1 g PPP, which was significantly higher than the control. Among all the treatments, the control treatment exhibits maximum moisture content of 86.4 ± 0.31 g/100 g which is significantly ($p \leq 0.05$) higher than TPM4 and TPM5. During the analysis of the results, it was observed that the incorporation of MFE and PPP did not have an impact on the fat and lactose content in dahi. The protein in all the treatment dahi was found to be slightly higher 3.3 ± 0.08 g/100 g, as compared to control by the value of 3.2 ± 0.08 g/100 g. Similarly, the maximum level of ash 1.0 ± 0.04 g/100 g was found to be in TPM5, which was significantly ($p \leq 0.05$) higher than control, followed by TPM1. This increment might be due to a higher level of incorporation of pine-apple pomace powder. As for ash content, the total solids content was found to maximum of 16.0 ± 0.09 g/100 g in TPM5, which was significantly higher than control and TPM1 by the value of 13.6 ± 0.31 and 13.8 ± 0.05 g/100 g respectively. Syneresis refers to the process of whey or serum being released or accumulated on the surface of a gel. A high syneresis value implies that the gel bond is unstable. While estimating syneresis in dahi treatments, it was noted that TPM5 exhibited the maximum level of syneresis, i.e., 14.75 ± 0.41 (ml/100 g), followed by TBM4 > TBM3 > TBM2 > TBM1, and the Control on day 1, as tabulated in Table 2. The maximum level of carbohydrates was 8.2 ± 0.05 g/100 g and 76.7 ± 0.26 kcal/100 g found in

Table 2 Physicochemical analysis of consumer oriented dahi

Parameters	Control	TPM1	TPM2	TPM3	TPM4	TPM5
pH	4.60 ± 0.37^{a}	4.56 ± 0.36^{ab}	4.51 ± 0.36^{bc}	4.48 ± 0.25^{cd}	4.42 ± 0.11^{de}	4.39 ± 0.17^{e}
TA %	0.75 ± 0.02^{e}	0.82 ± 0.01^{d}	0.91 ± 0.02^{c}	0.94 ± 0.06^{c}	1.05 ± 0.04^{b}	1.13 ± 0.08^{a}
Moisture (g/100 g)	86.4 ± 0.31^{a}	86.2 ± 0.05^{ab}	85.6 ± 0.38^{b}	85.0 ± 0.12^{c}	84.4 ± 0.30^{d}	84.1 ± 0.12^{d}
Fat (g/100 g)	3.4 ± 0.05^{a}	3.4 ± 0.08^{a}	3.4 ± 0.06^{a}	3.4 ± 0.08^{a}	3.4 ± 0.08^{a}	3.4 ± 0.05^{a}
Lactose (g/100 g)	4.3 ± 0.08^{c}	4.3 ± 0.01^{c}	4.2 ± 0.09^{c}	4.2 ± 0.05^{c}	4.6 ± 0.08^{b}	4.8 ± 0.05^{a}
Protein (g/100 g)	3.2 ± 0.08^{b}	3.3 ± 0.08^{ab}	3.3 ± 0.08^{ab}	3.3 ± 0.08^{ab}	3.34 ± 0.02^{a}	3.3 ± 0.08^{ab}
Ash (g/100 g)	0.7 ± 0.01^{c}	0.8 ± 0.02^{bc}	0.8 ± 0.08^{bc}	0.8 ± 0.05^{bc}	0.9 ± 0.04^{ab}	1.0 ± 0.04^{a}
TS (g/100 g)	13.6 ± 0.31^{c}	13.8 ± 0.05^{c}	14.2 ± 0.21^{c}	15.0 ± 0.09^{b}	15.6 ± 0.47^{ab}	16.0 ± 0.09^{a}
Syneresis (ml/100 g)	11.56 ± 0.84^{b}	11.89 ± 0.51^{b}	12.02 ± 0.32^{b}	12.73 ± 0.67^{b}	14.21 ± 0.55^{a}	14.75 ± 0.41^{a}
Carbohydrates (g/100 g)	6.3 ± 0.09^{e}	6.3 ± 0.22^{e}	6.9 ± 0.05^{d}	7.5 ± 0.09^{c}	7.9 ± 0.09^{b}	8.2 ± 0.05^{a}
Energy (kcal/100 g)	68.6 ± 0.05^{e}	69.6 ± 0.60^{d}	71.2 ± 0.50^{c}	73.1 ± 0.68^{b}	75.9 ± 0.05^{a}	76.7 ± 0.26^{a}
Colour						
$L*$	68.01 ± 0.02^{a}	64.2 ± 0.05^{b}	62.1 ± 0.12^{c}	61.3 ± 0.08^{d}	59.3 ± 0.09^{e}	58.3 ± 0.12^{f}
$a*$	-2.65 ± 0.01^{f}	1.3 ± 0.08^{e}	1.9 ± 0.05^{d}	2.5 ± 0.05^{c}	2.9 ± 0.05^{b}	3.7 ± 0.08^{a}
$b*$	14.1 ± 0.12^{e}	14.9 ± 0.05^{d}	15.2 ± 0.05^{c}	15.2 ± 0.05^{c}	16.2 ± 0.05^{b}	16.9 ± 0.12^{a}
$C*$	13.8 ± 0.12^{e}	14.9 ± 0.05^{d}	15.3 ± 0.08^{c}	15.4 ± 0.05^{c}	16.4 ± 0.08^{a}	17.3 ± 0.08^{a}
H*ab*	-5.3 ± 0.08^{f}	11.5 ± 0.08^{a}	8.0 ± 0.05^{b}	6.1 ± 0.12^{c}	$5.6 \pm 0.10.08^{d}$	4.6 ± 0.08^{e}
TCD (ΔE*)	68 ± 0.00^{a}	65.9 ± 0.08^{b}	63.9 ± 0.05^{c}	63.2 ± 0.08^{d}	61.5 ± 0.24^{e}	60.8 ± 0.05^{f}

All the values are presented as (Mean ± SD), and different superscript along each row denotes significance differences at $p \leq 0.05$

treatment TPM5, which was significantly higher ($p \leq 0.05$) than control followed by TPM1 and TPM2.

While accessing the colour coordinates values L^* (luminosity), $a*$(red-green), and $b*$(yellow-blue), chroma (purity and intensity and colour), hue angle (H_{ab}), and TCD(ΔE*) is a significant difference ($p \leq 0.05$) was observed among all the treatment as presented in Table 2. The Control treatment showed maximum L^* (luminosity) among all, whereas the TPM5 showed maximum a*(redness) and $b*$(yellowish) values. The Chroma ($C*$) or intensity of colour, which indicates the dullness or brightness of colour, the maximum $C*$ value was observed in TPM5 and TPM4 by the value of 17.3 ± 0.08 and 16.4 ± 0.08 respectively. The hue angle (H*ab*) is considered a qualitative colour attribute that is used to define the red (360 to 0°), yellow (90°), green (180°), and blue (270°) colours. While estimating the H*ab* and TCD (ΔE*), a significant difference was observed among the treatments, which indicates the incorporation of PPP and MFE significantly affects the color profile of dahi.

Limited studies have been documented in the literature regarding the utilization of Monk fruit extract (MFE) or its derivatives, such as pulp or juice, as a natural sweetener in fermented dairy products. In a recent study conducted by Ban et al. (2020b), yoghurt was prepared by adding 1 g of MME to 1L of milk. The authors reported that the incorporation of MME resulted in a significant reduction in the pH of the yoghurt, while the other parameters did not have a considerable effect on the physicochemical properties of the yoghurt. Similarly, Buchilina and Aryana (2021), conducted a study on the preparation of camel milk yoghurt using monk fruit at varying concentrations ranging from 0.42 to 2.54 g/L. The results of the study indicated that the addition of monk fruit extract led to an increase in the viscosity of the yoghurt, while also causing a decrease in its pH. Based on these findings, the authors concluded that the incorporation of monk fruit extract has a significant impact on the physicochemical properties of camel milk yoghurt. Furthermore, the authors suggest that the MME has potential as a low-calorie, health-promoting sweetener for yoghurt, which may be beneficial for individuals with diabetes. In another study, monk fruit pulp was added to fermented camel milk to examine the physicochemical, sensory acceptability, and biological effects on hyperlipidemic rats (Atwaa et al. 2023). Based on the results, the author concluded that adding monk fruit pulp (MMP @ 10%) as a supplement is most appropriate because it simultaneously improves the nutritional value. Additionally, rats' kidneys and liver function are improved by MMP administration. According to Sah et al. (2016), yoghurt can be made using pine-apple pomace powder (1% w/v), which has been oven- and freeze-dried. Based on the findings, the authors concluded that the nutrients in pineapple pomace have prebiotic effects on the cultures of *S. thermophilus* and *L. bulgaricus* and other probiotic strains. In addition to this, the author claimed that adding pineapple pomace powder considerably increases the anti-oxidant and anti-mutagenic effects. Similarly, Meena et al. (2022a) conducted a study in which the author used concentrate fibre fraction PPP at different levels (0.1%, 0.25%, and 0.5%) in the manufacturing

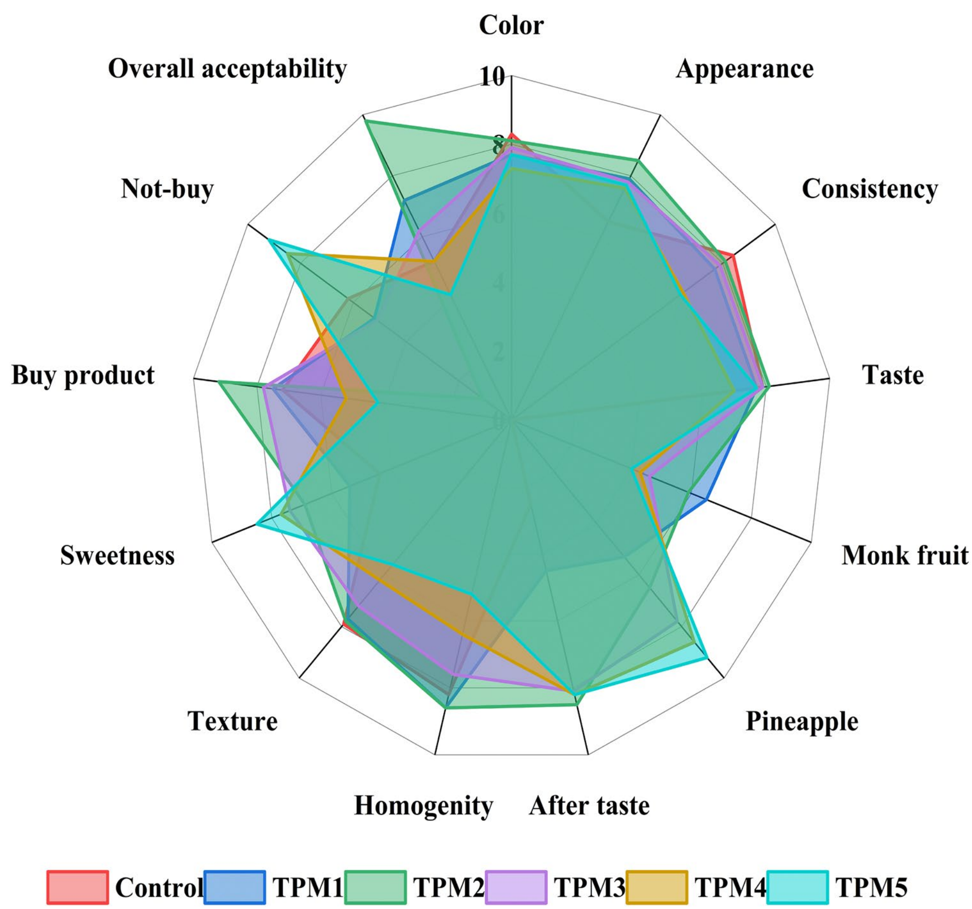

Fig. 2 Sensory evaluation of consumer-oriented dahi

of yoghurt, and concluded that the PP is a novel ingredient that elevates the techno-functional properties of yoghurt without affecting its rheological properties.

Sensory evaluation

Figure 2 depicts the organoleptic acceptance and customer purchase intention for dahi samples. The results of the sensory evaluation indicate that TPM2 was the preferred treatment in terms of appearance, taste, and after-taste. In contrast, TPM5 demonstrated an excessive pineapple flavour, whereas TPM1 displayed a more pronounced monk fruit flavour. However, the sensory panelists imposed suggest that TPM2 attained a satisfactory equilibrium between taste and flavor. Furthermore, the findings indicate that the dahi with the maximum sensory acceptability is TPM2, followed by TPM3. Conversely, TPM5 exhibits the lowest level of sensory acceptability. When accessing buying intentions, the TPM2 was the most likely to be bought, while the TPM5 was the least likely. Based on the obtained results and sensory analyst feedback, we conclude that the dahi formulation TPM2 exhibits potential for industrial-scale production, hereby catering to wider consumer acceptability as well as bringing a novel dahi variant to replace existing ones.

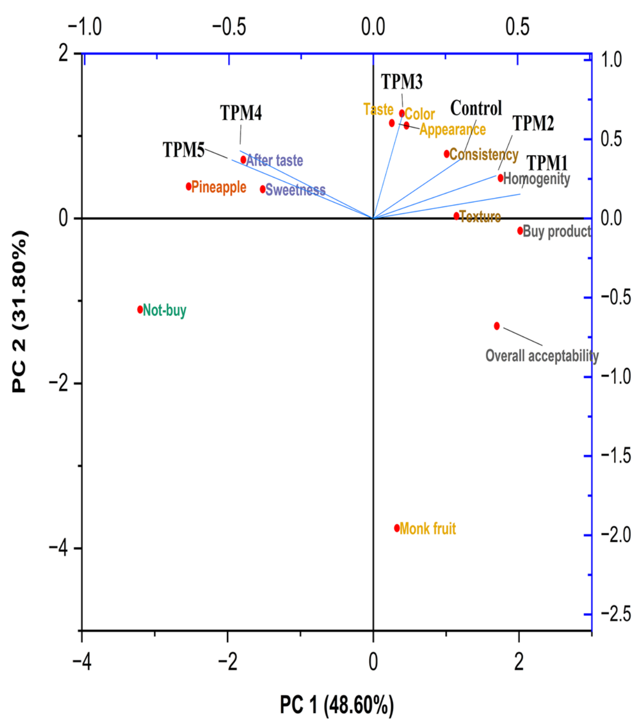

Fig. 3 Projection variables (Sensory and purchase intentions) on the factor plane- Scores plot of dahi treatment

Multivariate analysis

The implementation of multivariate analysis serves as a static methodology to verify whether the sensory parameters possess the capability to distinguish between the various Dahi treatments as perceived by the panelists. Figure 3 depicts the projection variables (Sensory and purchase intentions) on the factor plane-scores plot of dahi treatments. Obtained sensory results were analyzed by principal component analysis (PCA). The first two principal components (PCs), with Eigenvalues greater than 1 (2.92 & 1.91) were obtained by Kaiser Criterion of PCA. The first two principal components of PCs showed a variation cumulatively of 80.40%, specifically the first (PCI) and second (PCII) principal components that explained the variance of 48.60% and 31.80% respectively. The first component (PC1) explains 48.60% of variability which was mostly dominated by not-buy, buy-product, overall acceptability, and monk fruit. Where, the second component (PC2) explains 31.80% of the variability which was mostly dominated by colour, appearance, consistency, homogeneity, texture, after-taste, pineapple, and sweetness. Several researchers implemented multivariate techniques, particularly principal component analysis (PCA), to differentiate and categorize the sensory attributes of food items (Ghosh and Chattopadhyay 2012). For instance (Yilmaz-Ersan and Topcuoglu 2022) successfully employ PCA, to differentiate the sensory parameter of probiotic yogurt fortified with almond milk, (Dias et al. 2020) in low-fat probiotic yogurt, (Soukoulis and Tzia 2008) in frozen yogurt.

In order to determine the correlation among different dahi parameters, a Spearman correlation was applied to the data at a confidence level of 95%, as illustrated in the lower triangular matrix labelled by the correlation coefficient (Fig. 4). Based on the obtained findings a negative correlation was obtained between TPM4 and TPM1 ($r = -0.42$) and TPM4 and TPM2 ($r = -0.39$), where the TPM5 showed a negative correlation with control ($r = -0.20$), TPM1 ($r = -0.44$), and TPM2 ($r = -0.47$). However, the other dahi treatments showed a positive significant ($p < 0.05$) correlation with each other that indicates the incorporation of pine-apple pomace powder together with monk fruit significantly affects the organoleptic attributes of dahi.

Storage study

The dahi samples were subjected to pH, titratable acidity and syneresis analysis at regular intervals of 1 and 5 days, as illustrated in Fig. S2a, b & c. The pH levels dropped during storage for all treatments, including the control. The pH dropped from 4.60 to 4.50 in the control sample and from 4.39 to 4.02 in the TPM5 group. The titratable acidity (TA) and syneresis (TPM5) both increased from 0.75 to 0.81 and 1.13 to 1.34, respectively, after 5 days of storage. Figure S2c shows that after 5 days of storage, the syneresis in the control treatment rises from 11.56 to 13.05, whereas the

Fig. 4 Correlation analysis of consumer-oriented dahi

maximum syneresis is observed in TPM5, rising from 14.75 to 19.11. The elevated syneresis observed in the treated dahi could be attributed to the increased concentration of PPP. In addition, syneresis arises from the contraction of the three-dimensional (3D) configuration of the protein network, resulting in a reduced ability of whey protein to bind and its subsequent separation from dahi. A similar trend in the reduction of pH, increasing titratable acidity and syneresis during storage was also reported by Meena et al. (2022a) in PPP-incorporated yogurt.

Conclusion

The present study aims to investigate consumer preferences and offer a product that aligns with their demands, ultimately increasing the likelihood of purchase. Based on obtained observed, here we conclude that the consumer preference questionnaire (CPQ) is therefore be used to understand consumer preference towards products which drove us to offer a novel product in the market that meets consumer demands. The incorporation of pineapple pomace powder and monk fruit extract in the specified concentrations produces dahi with desirable sensory characteristics and considerable nutrition to meet consumer demand. Furthermore, the monk fruit has the potential to serve as a natural sweetener, while the pineapple pomace powder can function as a natural stabilizer, an abundant source of polyphenols, fiber, and natural colour and flavor enhancer. In addition to its intended purpose, this method also facilitates the efficient utilization of pineapple pomace waste. In addition, the substitution of sucrose with monk fruit concentrate in small quantities is sufficient in achieving a desirable level of sweetness which also imparts a distinct flavour. Based on the obtained results and sensory analyst feedback, conclude that the dahi formulation TPM2 exhibits potential for industrial-scale production, hereby catering to wider consumer acceptability as well as bringing a novel dahi variant to replace existing ones.

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Authors' contributions R.M and S.K. conceived and designed the experiments. S.G and R.K. performed the experiments; R.M. has contributed to data analysis and interpretation. H.K and S.K analyzed the data and wrote the paper. All authors read and approved the final manuscript.

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Data availability The data generated during this study and supporting this study are included in this article. The dataset analyzed during the current study is available from the corresponding author on a reasonable request.

Code availability Not Applicable.

Declarations

Conflict of interest There are no conflicts to declare. The authors declare that they have no conflict of interest and no competing financial interest. A patent application with application number 202311051696 and the title "A method and process of making consumer-oriented "Dahi" using pineapple pomace and monk-fruit as a sweetener" has been published by the Indian Patent Office.

Ethical approval Not Applicable.

Consent to participate All authors have read and approved the revised manuscript and informed of the submission to JFST.

Consent for publication The authors give their consent for the publication of the manuscript, which includes figures and tables within the text to be published in the Journal of Food Science and Technology.

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