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Effect of oat β -glucan on the rheological and sensorial properties of chocolate milk drink

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Abstract

In this study, the chocolate milk drink (CMD) was prepared by adding oat flour and maltodextrin in different levels followed by sterilization at 121°C. Oat contains soluble fiber β -glucan which increased the viscosity and improved the sensory properties of CMD. The addition of oat flour in the preparation of CMD increased the flavour, colour and appearance, mouthfeel, sweetness and overall acceptability of the product. The CMD without oat flour and 3% maltodextrin obtained lowest sensory scores for all the sensory attributes. The CMD30 scored highest score for colour and appearance, flavour, sweetness, whereas CMD21 (2% oat flour and 1% maltodextrin) scored highest score for mouthfeel attribute. The overall acceptability scores were highest for CMD21 due to the optimum mouthfeel and consistency of the product. The sensory scores of all the CMD samples were decreased during storage period of 21 days at 25±1°C. The sensory scores decreased might be due to the increase in acidity which might resulted in decrease in flavour and sweetness scores, the mouthfeel scores were decreased due to the increase in viscosity which ultimately decreases the overall acceptability of CMD. The CMD21 was found more acceptable than other samples because its mouthfeel was better than other experimental samples in the freshly prepared product and even in the stored product.

Keywords: Chocolate milk drink, oat flour, soluble fiber, viscosity, sensory attributes

Introduction

The market of functional food is increasing due to the increasing awareness among consumers about their health promoting properties. These days consumers are willing to consume foods which provide health benefits beyond basic nutrition. In global scenario, the market size of functional food ingredients was valued at USD 129.95 billion in 2025 and it expected to reach USD 236.86 billion by 2034 (fortunebusinessinsights.com). The functional food ingredients such as ω -3 fatty acids, plant sterols, probiotics, prebiotics, bioactive peptides can be added in food or dairy products to prepare foods which provides specific health benefits to the host [1].

The health promoting properties of soluble dietary fibre derived from cereal sources has been observed over recent decades due to their health benefits. The consumption of dietary fibre is increasing due to their health implications in reducing the risk of several chronic non-communicable diseases, including hypertension, impaired insulin response, obesity, and colorectal cancer [2].

Oat (*Avena sativa*), is an excellent source of soluble dietary fiber β -glucan [3] and also considered as potential bioactive components present in cereals [4]. Oats along with soluble fiber β -glucan are rich in lipids, protein, B-vitamins, minerals, plants, fats, α -tocopherol [5] and specific micronutrients and also it acts as a unique source of polyphenols (avenanthramides) [6]. It is also an excellent source of energy, unsaturated fatty acids [5] and volatile compounds [7] and lower in carbohydrates than other whole grains.

β -Glucan is a non-starchy polysaccharide composed predominantly of glucose units linked by mixed (1→3), (1→4) glycosidic linkages. In oats, the glucose monomers are specifically linked via β -(1→4) and β -(1→3) glycosidic bonds. Commercially, β -glucan is extracted and produced from a variety of natural sources, including oats, barley, mushrooms, and certain microorganisms.

The β -glucan content varies considerably across cereal grains, constituting approximately 1% in wheat, 3-7% in oats, and 5-11% in barley [4]. Consumption of β -glucan is associated with numerous beneficial health effects, encompassing immunomodulatory activity through

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enhancement of host defence mechanisms, potent anti-tumor properties against both benign and malignant neoplasms, and a significant reduction in serum cholesterol levels as well as postprandial blood glucose levels. Additionally, β -glucan has been reported to exhibit skin rejuvenating properties, favorable modulation of insulin responses, and several other physiological benefits [2].

Ingredients such as cereals and other organic materials have the ability to be a fat substitute, bulking agent, low-calorie sweetener, and texture modifier when added to dairy products, therefore potentially altering the sensory perception of the product [8]. The oats β -glucan are being incorporated in dairy and food products for its technological significance. It helps in the controlling the texture of various food products and have been used as a fat replacer in dairy, meat, and bakery products [9]. Another use of oat β -glucan as stabilizer in flavoured milk, dahi, yoghurt, ice cream and other dairy products. Many workers used oat β -glucan in the manufacture of cheddar and white-brined cheeses [10]. Oat β -glucan due to its thickening and/or gelling properties is used in the food industry [11]; it may also influence the sensory quality of beverages as it provides rich mouthfeel to the product.

Oat β -glucan when incorporated into dairy products also showed significant viscoelastic properties. The potential benefit of β -glucan in food is related to its rheological properties, mainly its ability to increase viscosity and increase gel forming capacity in the aqueous systems, the addition of β -glucans to dairy systems is an attractive option [12].

Milk is considered as almost complete food because it all the essential nutrients required by the body such as proteins, vitamins, minerals, essential fatty acids, etc. Flavoured milk or milk drinks is the second largest consumed liquid dairy product world-wide because of their pleasant flavour and flavour and also due to rich mouthfeel. Milk drinks can be an excellent medium to supply nutrition to the peoples of all age groups. Children's and teenagers consume the flavoured milk more than plain milk, due to their taste and for carrying a greater number of nutritional elements as compared to other beverages [13].

Milk contains all essential nutrients but lack in soluble fiber which acts as a prebiotic and facilitates the growth of favourable micro-organisms in the gastrointestinal tract (GIT). In this study, chocolate milk drink was developed by adding oat flour in different concentrations as a stabilizer and also as a prebiotic agent, and their rheological and sensorial studies of the prepared product was studied.

Materials and Methods

Materials

Skim milk was obtained by skimming the cow milk to less than 0.5% fat. Oat flour, sugar and cocoa powder were purchased from the local market of Raipur. Glass bottles used for packaging of milk drink was purchased from local market.

Preparation of β -glucan supplemented chocolate milk drink: The oat β -glucan supplemented chocolate milk drink (CMD) was developed by following the method of Chatterjee and Patel [14] with slight modifications. The skim milk was preheated to 45°C followed by addition of sugar @7%, oat flour in different concentrations (1, 3 and 5%) and maltodextrin in different concentrations (1, 2 and 3%).

The control sample was prepared using maltodextrin @3% as a stabilizer and without oat flour. The mix was further homogenized in two stage homogenizer at 2000 and 500 psi in the first and second stage, respectively to form homogenous mixture followed by sterilization in glass bottles at 121°C for 15 min at 15 psi. The product was stored for 21 days at 25±1°C and rheological and sensorial studies was conducted.

Rheological characterization of CMD

Viscosity of CMD: The viscosity of CMD was determined using Anton par rheometer (MCR-052) using cone and plate geometry (CP-75) at controlled temperature of 25±1°C. The analysis was conducted in triplicate and viscosity values was measured in cP.

Sensory evaluation of CMD

Sensory evaluation of control and experimental samples of CMD were organoleptically evaluated as per 9 point Hedonic scale.

Statistical Analysis

Statistical analysis of CMD was carried out using Analysis of Variance (ANOVA). The replicated values of different treatments were used for statistical analysis of CMD.

Result and discussion

Viscosity and flow curve

The viscosity of CMD added with oat flour and maltodextrin in different levels are presented in Table 1. The viscosity of CMD samples were increased with an increase in the concentration of oat flour, with highest viscosity was found in CMD with 3% oat flour (CMD30), whereas the lowest viscosity was observed in CMD without oat flour and 3% maltodextrin (CMD03). The addition of oat flour and maltodextrin as stabilizer increased the apparent viscosity of CMD. The variation of stabilizers in CMD also affected the viscosity. The viscosity of CMD ranged from 2.31 to 8.53cP.

Oat contains high percentage of starch. The heating of oat flour leads to morphological changes in the granule structure [15, 16]. The viscosity of CMD might be due to the gelatinization of oat starches occurred during heating process. During gelatinization process, the leaching of amylose and amylopectin occurs at 95°C which was responsible for increase in viscosity of CMD after sterilization process. Oat flour increases the viscosity of aqueous solutions resulting in increasing the palatability of the product by providing the desired consistency and mouthfeel in the product [11, 17]. The study conducted on yoghurt added with oat flour by [18] reported that the yoghurt with oat flour was more viscous than yoghurt without oat flour. The reason for increased viscosity was associated with the higher water absorption index of oat flour.

Effect of oat flour on the sensorial properties of CMD

Sensory quality of food products is a widely used method in order to test the organoleptic properties [19]. The effect of addition on oat flour on the sensory attributes like colour and appearance, flavour, sweetness, mouthfeel and overall acceptability of fresh and stored sample of CMD are presented in Table 2. The CMD samples were analysed for sensory properties on 0th, 7th, 14th and 21st day.

Colour and appearance of CMD

The colour and appearance score of CMD prepared using different concentrations of oat flour and maltodextrin are presented in Table 2. The highest score for colour and appearance was obtained by CMD21 (7.85), whereas the lowest score was 7.52 in CMD03 i.e. CMD without oat flour and 3% maltodextrin. The statistical analysis showed significant difference among samples of CMD. The colour and appearance score was significantly decreased ($P < 0.05$) during storage period of 21 days. The highest colour and appearance score among all CMD samples were recorded in CMD30.

The increase in the concentration of oat flour slightly increased the colour and appearance scores in the CMD samples. The CMD30 had obtained the highest score for coloured and appearance due to the higher concentration of oat flour [20]. also reported that the increase in the concentration of oat flour increased the colour score of yoghurt on increasing the concentration of oat flour from 0 to 1%. In another study of Ramanathan and Sivakumar [21], the incorporation of oat flour (1%, 2%, 3% and 4%) in the preparation of dahi increased the colour and appearance score at 1% and 2% oat flour concentration, upon increasing further concentration, the score was decreased. Chatterjee and Patel [14] also reported for high colour and appearance score in milk drink with oat flour compared to milk drink without oat flour.

During storage period, the colour and appearance scores was decreased and that might be due to the maillard reaction that occurred between available sugar and proteins in synbiotic milk drink during storage period. Kale *et al.* [22] also reported for decrease in colour and appearance scores of value added dahi (VAD) added with oat flour during storage period of 7 days at 5°C.

Flavour of CMD

The flavour scores of CMD added with oats are presented in Table 2, with highest and lowest scores for flavour attributes were obtained by CMD30 (7.95) and CMD03 (7.55), respectively. The addition of oat flour contributed in the flavour scores of CMD, the increase in oat flour concentration increased the flavour scores in the product. The improved scores of CMD samples may be attributed to the addition of oat flour, as oat is a complex collection of volatile flavour components [23]. Mahrous *et al.* [20] prepared yoghurt with the incorporation of oat flour and reported that with an increase in the concentration of oat flour, the flavour scores of yoghurt were increased.

The flavour scores for CMD were significantly decreased ($P < 0.05$) during 21 days of storage period, the highest flavour scores were obtained by CMD30. The decrease in the mean flavour score might be attributed to increase in acidity and other bio-chemical changes that takes place during storage. The decrease in flavour score in oat added dahi was reported by Kale *et al.* [22] where they reported that during storage period, the flavour scores were decreased from 8.89 to 8.67 at the end of storage period.

Sweetness of CMD

The highest sweetness score among CMD samples were found in CMD30 (7.85), whereas the lowest scores for sweetness was in CMD03 (7.68). The results showed that the addition of oat flour had contributed in the sweetness and taste attributes of CMD samples. The variations in

sweetness scores of fresh samples could be attributed to different levels of oat flour added with constant sugar level. Ramanathan and Sivakumar [21] also found similar results when they prepared dahi added with oat flour, reported that addition of oat flour improved the sweetness score of dahi. Kale *et al.* [22] reported that the addition of oat flour in the preparation of dahi had obtained high scores for sweetness attribute. Chatterjee and Patel [14] reported for high sweetness score in chocolate flavoured milk with oat β -glucan compared to chocolate flavoured milk without oat β -glucan.

During storage, the sweetness scores were decreased significantly ($P < 0.05$) with highest and lowest score was observed in CMD03 (7.32) and CMD30 (7.56), respectively. The score for sweetness was decreased might be attributed to the slight increase in the acidity during storage.

Mouthfeel of CMD

The mouthfeel scores of CMD with different levels of oat flour and maltodextrins are presented in Table 2. The mouthfeel of the CMDs were affected by varying the oat flour levels, with highest mouthfeel score was observed in CMD21 (7.95) and lowest in CMD03 (7.43). The addition of oat flour to a certain level provides the desired consistency and mouthfeel in the CMD, higher level tends to produce product with somewhat higher viscosity which was not much liked by the judges of sensory panel. The CMD30 had obtained slightly less mouthfeel score (7.89) than CMD21 because it contains 3% oat flour which results in more viscous product and decreases the mouthfeel score. The result obtained from this work indicated that the addition of oat flour above 2% levels may produce highly viscous product which resulted in the product which lacks in drinkable consistency. The addition of oat flour along with maltodextrin had provided desired consistency and mouthfeel in the CMD samples. Oat contains fiber which contributes in improving the mouthfeel of the product.

Mahrous *et al.* [20] added oat flour in different concentrations in the formulation of yoghurt and reported for increase in the mouthfeel scores of yoghurt with and increase in the concentration of oat flour. Chatterjee and Patel [14] also reported the improved scores for mouthfeel in chocolate flavoured milk when added with oat β -glucan. The incorporation of oat soluble fiber β -glucan to low fat dairy products can improve the mouthfeel of the product as well as other sensory properties to more closely resemble high-fat products [24].

During storage, the mouthfeel score was significantly decreased ($P < 0.05$), with highest mouthfeel score was observed in CMD21 (7.66) and lowest in CMD03 (7.25). The decrease in mouthfeel score during storage might be attributed to enzymatic changes and increase in the viscosity of CMD. The low-calorie milk drinks developed by Mittal & Bajwa [25], reported for significant decrease in the mouthfeel score during storage period. In another study, Bajwa & Mittal [26] reported for significant decrease in the mouthfeel score of sterilized flavoured milk drink during storage.

Overall acceptability of CMD: The overall acceptability scores of developed CMD are presented in Table 2, with highest score for overall acceptability was observed in CMD21 (7.89), whereas the lowest score for mouthfeel was recorded in CMD03 (7.55). The sample CMD30 had

obtained highest scores for colour and appearance, flavour and sweetness, and CMD21 scored highest score for mouthfeel which is the most important attribute when it comes to flavoured milk or milk drink as it decides the drinkable consistency of the product. Statistically, the CMD samples added with different levels of oat flour didn't show any significant difference ($P>0.05$) among them, however, they were significantly different ($P<0.05$) from CMD without oat flour (CMD03).

The addition of oat flour in different in CMD had showed considerable effect on overall acceptability of the product. The similar trend for overall acceptability scores in chocolate flavoured milk was reported by Chatterjee and Patel ^[14] where addition of oat β -glucan improved the overall acceptability of the flavoured milk compared to flavoured milk devoid of oat β -glucan. The addition of oat in yoghurt significantly improved the overall acceptability scores as reported by Brennan and Tudorica ^[12]. Ramanathan and Sivakumar ^[21] prepared dahi by adding oat flour at 1-2% and found that the overall acceptability scores of dahi was improved compared to dahi without oat flour. Mahrous *et al.* ^[20] also reported for increased overall acceptability scores in yoghurt incorporated with oat flour.

The overall acceptability scores of CMD were significantly decreased during storage period of 21 days, and CMD21 maintained the highest overall acceptability scores (7.70) even after 21 days of storage and the lowest score was observed in CMD03 (7.35). The overall acceptability scores of CMD with different oat flour levels showed non-significant difference between them but these samples were significantly different ($P<0.05$) from CMD without addition of oat flour (CMD03).

The decrease in overall acceptability of CMD might be attributed to various factors such as increase in acidity of CMD samples, the increase in viscosity to a level that makes product thick and of undesirable consistency which affected the mouthfeel score, and to some extent the certain biochemical changes that take place in any product would reduce the overall acceptability during storage. Kale *et al.* ^[22] prepared dahi by adding oat flour and reported for decrease in the overall acceptability scores from 8.92 to 8.14 during storage. The fruit flavoured milk-based beverage was developed by Hassan *et al.* ^[27] and reported for decrease in the overall acceptability score of the product during storage.

Table 1: Viscosity of CMD with varying oat flour concentration

Sample	Stabilizer concentration in milk drink (%)		Viscosity (cP)
	Oat flour	Maltodextrin	
CMD03	0	3	2.31 ^a
CMD12	1	2	3.92 ^b
CMD21	2	1	5.75 ^c
CMD30	3	0	8.53 ^d

CMD03: chocolate milk drink with 0% oat flour + 3% maltodextrin

CMD12: chocolate milk drink with 1% oat flour + 2% maltodextrin

CMD21: chocolate milk drink with 2% oat flour + 1% maltodextrin

CMD30: chocolate milk drink with 3% oat flour + 0% maltodextrin

Table 2: Sensory scores of CMD

Sensory Parameters	Treatments	Storage days			
		0 th day	7 th day	14 th day	21 st day
Colour and Appearance	CMD03	7.52 ^{aC}	7.40 ^{aC}	7.27 ^{aB}	7.03 ^{aA}
	CMD12	7.63 ^{aC}	7.45 ^{aB}	7.32 ^{aB}	7.24 ^{bA}
	CMD21	7.85 ^{bD}	7.68 ^{bC}	7.45 ^{bB}	7.25 ^{bA}
	CMD30	7.74 ^{bC}	7.55 ^{aB}	7.42 ^{bB}	7.29 ^{bA}
Flavour	CMD03	7.55 ^{aD}	7.43 ^{aC}	7.30 ^{aB}	7.12 ^{aA}
	CMD12	7.70 ^{bC}	7.57 ^{bB}	7.42 ^{aB}	7.21 ^{aA}
	CMD21	7.81 ^{bB}	7.67 ^{bcB}	7.52 ^{bcA}	7.41 ^{bA}
	CMD30	7.95 ^{dD}	7.79 ^{cC}	7.64 ^{cB}	7.45 ^{cA}
Sweetness	CMD03	7.68 ^{aC}	7.59 ^{aBC}	7.47 ^{aB}	7.32 ^{aA}
	CMD12	7.77 ^{bC}	7.63 ^{aB}	7.58 ^{aB}	7.37 ^{aA}
	CMD21	7.83 ^{bB}	7.78 ^{bB}	7.68 ^{bA}	7.57 ^{bA}
	CMD30	7.85 ^{bcB}	7.76 ^{bB}	7.62 ^{abA}	7.56 ^{bA}
Mouthfeel	CMD03	7.43 ^{aB}	7.35 ^{aAB}	7.33 ^{aA}	7.25 ^{aA}
	CMD12	7.77 ^{bB}	7.75 ^{bB}	7.65 ^{bA}	7.58 ^{bA}
	CMD21	7.95 ^{cAB}	7.92 ^{cAB}	7.86 ^{dA}	7.79 ^{cA}
	CMD30	7.89 ^{bcB}	7.85 ^{bcAB}	7.76 ^{cA}	7.66 ^{bA}
Overall Acceptability	CMD03	7.55 ^{aB}	7.49 ^{aAB}	7.41 ^{aA}	7.35 ^{aA}
	CMD12	7.81 ^{bB}	7.74 ^{bA}	7.69 ^{bA}	7.62 ^{bA}
	CMD21	7.89 ^{bB}	7.83 ^{bAB}	7.77 ^{bA}	7.70 ^{bA}
	CMD30	7.85 ^{bB}	7.79 ^{bB}	7.75 ^{bAB}	7.65 ^{bA}

CMD03: chocolate milk drink with 0% oat flour + 3% maltodextrin

CMD12: chocolate milk drink with 1% oat flour + 2% maltodextrin

CMD21: chocolate milk drink with 2% oat flour + 1% maltodextrin

CMD30: chocolate milk drink with 3% oat flour + 0% maltodextrin

Conclusion

This study highlighted the technological importance of oat soluble fiber β -glucan in the preparation of chocolate milk drink. The incorporation of oat flour in the chocolate milk drink significantly affected the viscosity and sensorial attributes of the product. Among all the CMD samples, the highest scores for colour and appearance, flavour and sweetness attributes was obtained by CMD30, whereas the highest mouthfeel score was obtained by CMD21 due to the increase in viscosity of CMD by incorporation of oat flour. It can be concluded that CMD21 was found more acceptable from rest of the samples as it has obtained highest scores for mouthfeel, a product can be acceptable even with uneven colour and flavour but it can only be acceptable with desired consistency and mouthfeel. The colour and appearance, flavour, sweetness, mouthfeel and overall acceptability scores was decreased during storage period.

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