

**PREPARATION OF GOAT MILK *SHRIKHANDWADI* SWEETENED BY
JAGGERY**

by

Miss. Villina Jujevas Noronha
(Reg. No. 019/140)



DIVISION OF ANIMAL HUSBANDRY AND DAIRY SCIENCE

RAJARSHEE CHHATRAPATI SHAHU MAHARAJ

COLLEGE OF AGRICULTURE,

KOLHAPUR

MAHATMA PHULE KRISHI VIDYAPEETH

RAHURI-413 722, DIST-AHMEDNAGAR

MAHARASHTRA, INDIA

2021

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A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI- 413722, DIST- AHMEDNAGAR
MAHARASHTRA, INDIA

In partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

DAIRY SCIENCE



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CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
thereof has not been submitted
by me or other person to any
other University or Institute
for a Degree or
Diploma

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CERTIFICATE

This is to certify that the thesis entitled, “**PREPARATION OF GOAT MILK SHRIKHANDWADI SWEETENED BY JAGGERY**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **DAIRY SCIENCE**, embodies the result of a piece of bonafide research work carried out by **Miss. NORONHA VILLINA JUJEVAS** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Place: Kolhapur
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ABSTRACT

**“PREPARATION OF GOAT MILK SHRIKHANDWADI SWEETENED BY
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by

NORONHA VILLINA JUJEVAS

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

DAIRY SCIENCE

2021

Research Guide	: Dr. D. D. Patange
Division	: Animal Husbandry and Dairy Science
Major Field	: Dairy Science

Shrikhand is consumed as a dessert after meals. It is prepared by fermentation of milk using known strains of lactic acid bacteria followed by draining of whey and addition of sugar and flavours to the drained curd. The partial evaporation of moisture by converting into solid confection (*Shrikhandwadi*) can be an excellent means to extend the shelf-life of Shrikhand. Jaggery is a natural traditional Indian sweetener and contains appreciable number of micronutrients with antitoxic, anticarcinogenic properties. Therefore, it was used in the preparation of goat milk *Shrikhandwadi*.

A preliminary study was carried out to know the sensory attributes, chemical composition, Hunter colour value, textural profile and physical attributes of market samples. For this four samples (M₁, M₂, M₃ and M₄) were collected from different markets. It was found that sample M₃ obtained maximum score for colour and appearance, flavour, body and texture and overall acceptability and the score were 7.30 ± 0.04 , 7.45 ± 0.03 , 7.90 ± 0.06 and 7.55 ± 0.06 respectively. *Shrikhandwadi* was prepared from goat milk milk containing 3.5 per cent fat. To know the effect of level replacement of jaggery to sugar, the jaggery was added @ 25, 50, 75, 100 and 125% of chakka and at the same time proportional amount of sugar was reduced. Control sample was prepared by addition of sugar @ 125% of chakka. The level of SMP in *Shrikhandwadi* was kept constant at 15% of chakka. Further the optimum drying conditions for *Shrikhandwadi* were optimized by drying *Shrikhandwadi* at 40, 50 and 60°C for 15 and 30 minutes. Finally, the optimized sample was compared with market sample M₃. The prepared *Shrikhandwadi* was analysed for sensory, physico-chemical properties, colour value and textural profile. The data thus obtained was analysed using Completely Randomized Design.

The results of the study revealed that the colour and appearance, flavour and overall acceptability score of *Shrikhandwadi* prepared by formulation of 50% jaggery and 75% sugar of chakka were 8.31 ± 0.06 , 8.29 ± 0.07 , 6.90 ± 0.06 and 7.83 ± 0.02 respectively. It was observed that addition of jaggery would improve the colour and appearance, flavour and overall acceptability upto certain extent but it adversely affected the body and texture.

Further the physico-chemical properties of *Shrikhandwadi* were recorded and it was found that the optimized product contained 7.19 ± 0.06 , 8.17 ± 0.01 , 13.18 ± 0.02 , 12.58 ± 0.02 , 57.18 ± 0.06 and $2.15 \pm 0.02\%$ moisture, fat, protein, reducing sugar, non-reducing sugar and ash respectively. The solubility and acidity were found to be 77.25 ± 0.06 min and $1.36 \pm 0.02\%$ respectively. It was found that with the increase in level of replacement of jaggery to sugar, the L^* and b^* values decreased whereas a^* values increased. The hardness, adhesiveness, springiness, cohesiveness, chewiness and guminess values of optimized product were found to be 33483.33 ± 41.9 , -9.28 ± 0.06 , 0.31 ± 0.06 , 0.24 ± 0.05 , 2153.70 ± 2.8 and 7549.79 ± 9.1 respectively.

Developed *Shrikhandwadi* was dried in cabinet air dryer. The *Shrikhandwadi* dried at 40°C for 15 min obtained maximum score for colour appearance, flavour, body and texture and overall acceptability which was found to be 8.26 ± 0.02 , 8.21 ± 0.04 , 8.24 ± 0.02 and 8.23 ± 0.02 respectively over the other drying conditions. The optimized product and best market sample were compared using 't' test and significant differences were found between the various attributes. The body and texture score of market sample was rated higher than experimental sample which indicates need to improve the experimental sample with respect to body and texture attribute.

1. INTRODUCTION

The products which are prepared by inoculating the milk with starter culture mainly Lactic Acid Bacteria (LAB) are referred to as fermented products in the dairy industry. These bacteria hydrolyze the milk lactose into lactic acid, thereby raising the acidity and decreasing the pH of milk. The fermentation is accompanied by formation of a gel, particularly the proteins. In some fermentation, alcohol is produced along with acids due to yeast or fungi. Fermented milk and fermented dairy products have inhabited an important place in satisfying the palate and nutrients required by humans from ancient time. Fermented milk is more palatable and more digestible than milk and is easily assimilated by the human system and contains beneficial antibodies. It also helps in improving bowel movement. Fermented dairy products improve immunity and absorption of minerals (Kanawajia., 2006).

About 400 fermented milk products are prepared in the world. Some of them are kefir, kumiss, bulgarian sour milk, dahi, yoghurt, acidophilus milk, lassi, shrikhand etc. In India, 7 per cent of the total milk production is utilized for preparing fermented dairy products which mainly consists of dahi, lassi and Shrikhand (Swapna and Chavannavar., 2013).

Shrikhand is a fermented, sweetened dairy product originated in India which is derived from the Sanskrit word 'shrikarini' meaning a curd prepared by adding sugar, flavouring material, dried fruits, etc. It is consumed on a regular basis in Maharashtra, Gujarat, and some parts of Karnataka, Madhya Pradesh and Rajasthan. Owing to its unique sweet-sour taste, it is gaining popularity in many parts of India. Shrikhand is typically semi-solid in consistency with a characteristic firmness, smoothness, and pliability due to which it becomes suitable to consume shrikhand directly after meals or with 'puree' or bread (Nigam *et al.*, 2009). As per FSSAI (2011) Shrikhand is the product that is derived from chakka or skim milk chakka with addition of fat along with sugar. It may contain fruits, nuts, sugar, cardamom, saffron and other spices and is blended to smooth and homogenous consistency. It must not contain any added colouring or artificial flavouring substances. Shrikhand should contain a minimum of 58 percent total solid, a minimum of 8 percent milk fat on a DM basis, milk protein minimum of 9 percent (on DM basis). Consumers in Gujarat prefer its sweet type while those in Maharashtra prefer the tangy/slightly sour type shrikhand (Aneja, *et al.*, 2002).

The shelf life of fermented milk products is restricted because of a lack of well-organized cold storage facilities (Gupta *et al.*, 2015). The shelf life of Shrikhand is 2 to 3 days at ambient temperature and its freshness is lost beyond 2-3 weeks of storage under refrigerated conditions due to a high percentage of moisture and microbial activity (Prajapati and Sreeja, 2013; Gupta *et al.* 2015; Senapati, 2016). People in many other countries like India consume fermented dairy products but it is problematic to export due to its short storage stability.

The preservative technology generally employed for food is dehydration or sterilization.

The drying or dehydration of dahi provides a great advantage in obtaining dahi powder, which can be regarded as convenient foods (such as raita and kadhi mix) and convenient ingredients in formulas. The formulation of healthy beverage mixes based on fermented dairy product (dahi) powder offers great potential for the Indian dairy industry, thanks to the health benefits of dahi and its sensory characteristics (Shiby and Mishra., 2007). One of the attempts has been made to prepare shrikhand in ready dry mix. It is expected that the powdered form of the premix is not only beneficial to the environment but also has the advantages of longer shelf life, minimal storage requirements and lower packaging costs. The powder mixture should be formulated so that it can be easily reconstituted in water to prepare shrikhand and be formulated when needed. The partial evaporation of moisture into solid confection by fortification can be an excellent means to extend the shelf life of shrikhand (Bramhapurkar *et al.*, 2007). Shrikhand is a semi-soft, sweetish-sour, whole milk product prepared from lactic fermented curd. The curd (dahi) is partially strained through a cloth to remove the whey and thus, produce a solid mass called chakka. This chakka is mixed with the required amount of sugar, etc. to yield shrikhand. The shrikhand is further desiccated over an open pan to make the *Shrikhandwadi* sweet. On an average *Shrikhandwadi*, contains 6.5%, 7.4%, 7.7%, 15.9%, 0.8%, 62.9% and 1% moisture, fat, protein, lactose, ash, sugar and lactic acid respectively (De., 2009).

Goat milk may be considered as an outstanding dairy alternate with the potential to replace traditional dairy products and to improve human health. Today, goat milk is of particular interest due to its unique composition, which has led to it being considered as raw material of high quality for manufacturing food for infants and for certain sectors of the population with particular needs (Nunez-Sanchez *et al.*, 2016). Goat milk contains 3.8% fat, SNF 8.9%, lactose 4.1%, protein 3.4%, casein 2.4%, ash 0.8% and 70 calories/100 mL (Park *et al.*, 2007). The non-digestible sugars present in goat milk act as prebiotics which help in maintaining the health of gastrointestinal tract. Oligosaccharides present in goat milk function as scavenger receptors of various pathogens, and perform anti-inflammatory functions. (Boehm and Stahl., 2007). Goat milk is a source of antioxidant peptides which can potentially prevent or delay oxidative deterioration of foods and extend shelf life. Therefore, it can be used to prepare various milk products, including *Shrikhandwadi* (Ahmed *et al.*, 2015).

Dairy products are mostly sweetened with sucrose however, jaggery can be used in the dairy products preparation (Gartaula and Bhattarai., 2014). Jaggery is an indigenous sweetener and is being manufactured in India since time immemorial. Last century witnessed the growth of white sugar manufacturing at the expense of the jaggery and the khandsari industry. White sugar contains only sucrose which leads to variety of health issues. Its excessive consumption causes coronary thrombosis, dental carries and other heart related problems. Contradictorily jaggery contains 51% sucrose, 0.25% protein, 21.2% glucose and 3.4% minerals in addition to trace

amounts of fats, iron, calcium and phosphates, which are absent in white sugar. In addition, it also possesses medicinal properties. Jaggery enjoys wide acceptability in rural India. Scientific production and storage of jaggery will encourage the jaggery cottage industry and provide a healthy alternative to white sugar (Gupta *et al.*, 2007).

Considering the scope for conversion of shrikhand into *Shrikhandwadi* and the increasing demand of milk and milk-based sweets, the problem undertaken for the present work carries much significance for commercialization of traditional Indian sweets. Furthermore, replacing sugar with jaggery has been attempted with the view to decrease sucrose consumption in the product. Thus the present research carries much industrial significance and is proposed with the following objectives.

1. To optimize the level of jaggery in *Shrikhandwadi*
2. To optimize the time-temperature combination for drying of *Shrikhandwadi*
3. To study the sensory and physico-chemical properties of *Shrikhandwadi*

2. REVIEW OF LITERATURE

Shrikhand is a semi-soft, sweetish-sour, whole milk product prepared from lactic fermented curd. The curd (dahi) thus, obtained is strained partially through cloth to drain the whey and produce a solid mass called chakka, which is essentially mixed with the required quantity of sugar, to yield shrikhand. The shrikhand is further desiccated over an open pan to make the *Shrikhandwadi* sweet. The research work was carried out on various aspects of shrikhand and *Shrikhandwadi* which have been reviewed as under.

2.1 Preparation of Shrikhand:

Singh and Jha (2005) developed a technique for producing shrikhand by partially replacing sugar using Raftilose[®], a commercial sugar replacer and dietary fiber. It involved separation of milk, pasteurization at 90°C for 16 seconds and cooling to 37±1°C. After which the milk was inoculated with 2 percent yoghurt culture and incubated at 42 ± 1°C. When the desired pH of 4.3 was achieved, the curd was transferred to a muslin cloth and *chakka* was obtained by draining of whey. They found that the sensory characters of shrikhand were most acceptable when sugar and Raftilose[®] were added @ 12.5 per cent and 4 per cent, of chakka respectively. The developed shrikhand had calorific value of 127.86 kcal/100g against 232.05 kcal/100g which was conventionally developed thus, enabling about 45 per cent reduction in the total calorific value.

Pal and Raju (2006) described the traditional method for preparation of shrikhand, which involves preparing curd or dahi by cultivating cow or buffalo milk with a natural starter (curd from previous batch). After the formation of curd, the curd should be transferred to muslin cloth for 12-18 hours to remove free whey. The resulting semi-solid mass is called chakka. The chakka was mixed with required amount of sugar, colours, flavoring materials and spices and blended to get uniform mixture uniform. Shrikhand can be stored and eaten in refrigerated form. In mass production, the quality of shrikhand differs greatly and the shelf life is very short, which is a serious defect of the traditional method. In general, the solid recovery rate of chakka is also very low.

Kulkarni *et al.* (2006) stated that the method of manufacturing shrikhand depends on the scale of its production. The traditional method is still widely used for small- scale production. In this method, milk is boiled, cooled and fermented by using starter culture to make yoghurt, followed by filtration of the same by using muslin cloth to remove the free whey. The chakka thus, obtained as thickened mass was strained over a strainer to give a smooth product which after addition of sugar gives shrikhand. On an industrial scale, shrikhand is made using different mechanical devices.

Sonawane *et al.* (2007) reported that shrikhand could be developed by fermenting milk with lactic acid bacteria, expulsion of whey from curd, followed by mixing with sugar, flavouring, spices and other ingredients like fruit pulp, nuts etc. to form a soft homogeneous mass.

De (2009) explained the process of preparing shrikhand. He stated that to prepare high quality shrikhand, fresh sweet buffalo milk (standardized to 6% fat, pasteurized at 71°C for 8-10 minutes, and then cooled to 28-30°C) is needed which is inoculated @ 1% lactic acid culture, then incubated at 28-30°C for 15-16 hours. The curd thus, obtained is then broken and placed on muslin cloth and the whey is drained for 8-10 hours. The product thus, obtained is chakka, to which sugar is added and kneaded and mixed uniformly to get shrikhand.

Mehta (2013) reported that shrikhand is a semi-soft sweet yoghurt product made from lactic acid-fermented curd. The curd is partially filtered through a muslin cloth to remove the whey, which produces a solid called chakka. It is the basic ingredient of shrikhand. Then the chakka obtained is mixed with an appropriate amount of sugar, found different aromas and varieties made by adding different pulps, dried fruits, saffron, cardamom and other spices.

Singh and Singh (2014) stated that shrikhand is a local semi-soft, sweet, sour, whole milk delightful dairy dessert, especially in western India. It is made up of chakka (strained curd/yoghurt), which is precisely mixed with flavouring agents and sugar as per requirement. Shrikhand has high nutritional value, flavour, taste, palatable properties and possible therapeutic value. It improves the digestive system and strengthens the immune system. This article reviews the use of shrikhand as a healthy food in our diet.

Srinivas *et al.* (2017) stated that shrikhand is an indigenous traditional fermented semi-soft, sweetened milk(whole) product prepared utilizing chakka (strained dahi). Further taste and appearance of the product can be improved by adding sugar and other ingredients like nuts, colours etc.

2.2 Utilization of Goat Milk in Dairy Products

Mehaia (2002) developed soft fresh white cheese made of goat milk by the use of ultrafiltration (UF) and conventional processes. The cheese made by the UF process had higher pH, moisture content and ash, whereas fat and protein contents were lower in comparison to cheeses that were made using conventional process. An increase of 21% in the yield of cheese, 21-26% in recovery of protein, 15-19% in fat recovery and 17-22% in total solids recovery was obtained by UF process. However, the UF process showed 83.3%, 83-85%, 75% and 82.5% reduction in salt, total process time, starter culture, calcium chloride and rennet used, respectively. The mean score for texture of cheeses made by the process of UF was significantly higher than that of cheeses made by traditional process.

Rodriguez *et al.* (2003) developed a procedure for preparing cultured goat cream butter. Goat milk cream was inoculated with mesophilic aromatic freeze-dried lactic cultures and upon inoculation it showed a rise in acidity and a lowering in the lactose content, with an increase in the concentration of lactic acid cultures. The optimal values of the fermentation process were inoculum dosage of 8.8 U/100 l and a fermentation time of 7 hr. at a temperature of 28°C. This

cultured formulation achieved optimum sensory score in appearance, texture, flavour and overall quality. At 15°C cultured formulation had ideal spreadability and was solid at 4°C. At a temperature of 18-25°C the solid fat content of the product was 8-11%.

Reddy *et al.* (2014) optimized the procedure for manufacturing spray-dried milk powder from Osmanabadi goat milk. The milk solid loads of 35, 40 and 45% and an air temperature (inlet) of 160, 170, and 180°C had been chosen as variables (independent) to manufacture the spray-dried powder. The proximate composition of spray dried Osmanabadi goat milk powder thus, obtained was viz., moisture content, carbohydrates, protein, ash and titratable acidity were 4.08%, 36.99%, 25.48%, 6.60% and 0.14%, respectively.

McGhee *et al.* (2015) manufactured three types of soft-serve low-fat goat milk ice-cream using milk with 3.64% fat, 2 percent fat and goat skim having fat percent of 0.71, that was evaluated for textural and sensory characteristics of the goat ice-cream products. A commercial vanilla flavoured powder pre-mix containing 0.25 percent fat was incorporated into the three types of goat milk base for the manufacture of the ice-cream, and the textural and sensory properties of the products were evaluated at 0, 2, 4, 8 weeks of frozen storage at -18°C. It was found that the sensory and textural qualities of the low-fat goat milk ice-cream were acceptable to the sensory panel after 8 weeks of frozen storage.

Bhat *et al.* (2016) developed a novel goat milk bar by incorporating rose flower extract as an added ingredient (concentration level: 0, 5, 10, 15 and 20%) and by using two different types of natural sweeteners (cane sugar and palm sugar). The nutritional bars were evaluated for the proximate composition, texture properties and sensory qualities. The results obtained were encouraging and the new goat milk based nutritional bar formulation with added rose extracts certainly paves the way for future commercial exploitation of the product. Goat milk owing to its rich nutraceutical value and rose extracts owing to the dual functions of a natural antioxidant and antimicrobial agent, can be beneficial in extending the shelf life of the novel product at room or refrigerated temperatures, thus, attracting better markets.

Serhan *et al.* (2016) prepared concentrated yoghurt (Labneh) from goat milk, cow milk and their mixture. Labneh produced from goat milk was characterized by its high moisture content, ash and fat content but lower pH, total solids, protein and lactose content in comparison to the Labneh developed using cow's milk. Labneh with goat's milk had a higher short and medium-chain fatty acids groups and a lower long-chain fatty acids than that only containing cow milk. Samples with 40% goat milk/60% cow milk were the most preferred by the sensory panel.

Silva *et al.* (2016) manufactured ice-cream from goat milk that was enriched with different proportion of carob powder. They found that goat milk ice cream containing carob powder at the rate of 12% was found to be most acceptable pertaining to all sensory attributes by the panel members.

Viji *et al.* (2017) made use of goat milk and buffalo milk in combination for preparation of paneer. Paneer was made with the mixture of goat and buffalo milk in different proportions. Freshly prepared paneer had a creamy white colour and had no goaty smell and salty taste. No significant changes in fat and moisture content of paneer were observed during refrigerated storage. The samples of paneer thus, obtained could be stored in refrigerated storage (4°C) upto 1 week and 1 day at room temperature (30°C) without degradation in quality. The use of goat milk at a level of 25% with buffalo milk showed an improvement in paneer yield.

Yadav *et al.* (2018) optimized the procedure for preparation of goat milk shrikhand blended with sapota pulp and betel vine leaf extract and studied its sensory properties such as colour and appearance, flavour and taste, consistency and overall acceptability using a 9-point hedonic scale. Treatments T₀, T₁, T₂, and T₃ were formulated in which goat milk shrikhand was prepared by using 30% sugar blended chakka, sapota pulp and betel leaf extract in the ratio of (100:00:00, 93:5:2, 88:10:2, 83:15:2) respectively. The sensory score for overall acceptability of goat milk shrikhand for treatments was 7.50, 7.74, 7.88 and 8.47 respectively. The overall acceptability score of goat milk shrikhand of treatment T₃ was 8.47 as compared to 7.50 for control.

2.3 Technologies for Production of Fermented Milk Products in Dried Form

Kumar and Mishra (2004) prepared yoghurt powder with the primary objective of preserving yoghurt in shelf-stable powdered form without refrigeration. Such a powder can be developed by various methods, viz. freeze - drying, spray - drying, microwave - drying and vacuum drying. Before drying, it is beneficial to concentrate yoghurt by different methods which include cloth bag method, mechanical centrifugation, ultrafiltration and vacuum concentration method. They found that *S. thermophilus* shows less sensitivity in comparison to *L. bulgaricus*, while freeze drying as well as during spray-drying of yoghurt and freeze-dried yoghurt can be stored for about 1–2 years at 4°C. After 1 year of storage, the powder contains total bacterial counts of 10⁶ cfu/g. Active cultures are guaranteed for 1 year under cool, dry conditions for spray-dried yoghurt; it can be utilized in the bakery and confectionary industries.

Shiby and Mishra (2007) studied air drying of dahi, for which buffalo milk was standardized to 4.5 percent fat and 10 percent solids-not-fat, mixed in high-speed mixer at 19000 rpm and was then pasteurized at 85°C for 15 min. The milk was then cooled to 22°C and inoculated with NCDC-167 @ 2.5 percent and incubated at 29°C for 16 h. Dahi was dried in a laboratory scale re-circulatory convective air dryer to final moisture content of 0.04 kg water/kg dry solid. Drying characteristics of dahi were investigated under various conditions of dahi.

Bramhapurkar *et al.* (2007) standardized the procedure for preparation of *Shrikhandwadi* blending of chakka, sugar (100%) and skim milk powder (15 %) in a shallow pan following heating. The thick mass obtained was then cooled and made into rectangular pieces and stored at room temperature.

Gupta *et al.* (2015) prepared a premix of shrikhand by using microencapsulated rice bran oil as a fat substitute and hydrocolloids as a texture modifier. Skim milk curd, skim milk powder, sucrose along with microencapsulated rice bran oil (RBO) as alternative for fat was used to develop a premix of shrikhand. RBO was microencapsulated by the use of spray drying under optimized conditions of air inlet temperature (135°C), feed rate (15 mL/h) and solid contents (17%) in emulsion. They found that Hicap-100 (modified starch) showed best encapsulation ($62.83 \pm 0.57\%$) to RBO in comparison to maltodextrin and gum arabica as wall material. The premix thus prepared was utilized to prepare shrikhand and the shrikhand thus obtained was compared to market sample in terms of texture, composition, sensory and profile colour. With the addition of xanthan and gellan gum (80:20), the texture of prepared shrikhand improved to level of shrikhand available in market.

Shiby and Pandey (2015) developed fruit lassi powder through D-optimal mixing design (with 2 factors at 5 levels) for the optimization of the mixing of two fruit lassi powders. The responses studied were overall acceptability and acidity of the formulations. The lassi: Pine apple juice and lassi: Musk melon pulp ratios selected on the basis of response analysis was 49:51 and 72:28 respectively. In both lassi powders 0.15% carboxy methyl cellulose and 8.5 % sugar were found to be acceptable. The level of juice/ pulp in the blend had significant effect on the quality of lassi powders. Freeze dried fruit lassi powders were analysed for proximate composition, physico-chemical and flow properties. pH, acidity of the reconstituted drinks was also estimated. The freeze-dried mixes had good colour, light weight and were instantly soluble in water. These products offer a healthful combination of dairy and fruit components with the added advantage of culture organisms and low lactose.

2.4 Chemical Composition of Fermented Milk Products in Dried Form

Date *et al.* (1955) revealed the chemical composition of *shrikhandwadi* made with chakka and sugar. The final moisture content was 6.5 per cent, fat 7.4 per cent, protein 7.7 per cent, ash 0.8 per cent, total sugar 62.9 per cent and lactose 15.9.

De (1980) declared that *Shrikhandwadi* contains moisture 6.5 per cent, fat 7.5 per cent, protein 7.7 per cent, lactose 15.9 per cent, titrable acidity 1.0 per cent and total sugar 62.9 per cent.

Kumar and Mishra (2004) reported the composition of various dried yoghurt powder. The final moisture content of the dried product varied from 5.1 to 6.3 per cent, protein 35-37 per cent, fat 1.5, lactose 45-50 and titratable acidity 5-8 per cent.

Bramhapurkar *et al.* (2007) gave the chemical composition of *Shrikhandwadi* made from chakka mixed with sugar and SMP. The moisture content of *Shrikhandwadi* (control at 125 per cent sugar) was 9.4 per cent which reduced to 8.3 per cent on fortification with 10 per cent SMP. The total solid, protein and total carbohydrate content were increased from 90.6, 7.7. and 69.1 to 91.7, 8.4 and 69.7 per cent, respectively.

Shiby and Pandey (2015) recorded that the lassi powder the lassi powder contained 2.8% moisture, 7.6% ash, 13.4% protein, 11.6% fat and 65.6% carbohydrates. The bulk density, rehydration time and water activity of the powder was 0.5g/cc, 1.5 minutes and 0.306 respectively. The energy value was 420 Kcal/100gm.

2.5 Proximate Composition, Properties and Utilization of Jaggery

Rao *et al.* (2007) stated jaggery as a natural traditional Indian sweetener which is nutritious and easily available to rural people and considered as a wholesome diet. It includes reducing sugars including glucose and fructose (10-15%), protein 0.4g, fat 0.1g, total minerals 0.6-10%, calcium 8gm, iron 1gm, moisture 8%, energy 383 Kcal per 100 gm of sugar.

Nayaka *et al.* (2008) had studied cytoprotective and antioxidant activity of jaggery. Total phenol content of jaggery were gallic acid, protocatechuic acid, gentisic acid, 4-hydroxyphenyl acetic acid. Vanillic acid, caffeic acid, syringic acid, p-coumaric acid, feullic acid, t-cinnamic acid etc. Both jaggery and brown sugar indicated cytoprotective abilities against tert-butyl hydroperoxide and hydrogen peroxide induces oxidative damage of NH₃T₃ fibroblasts and human erythrocytes, respectively.

Ubale^a *et al.* (2014) studied the preparation of sapota milkshake by addition of sapota pulp at 3 levels *i.e.*, 7, 8 and 9% sweetened with jaggery at 7, 8 and 9%. The sensory and chemical quality of sapota milkshake were carried out. On the basis of sensory evaluation, it was found that sapota milkshake prepared with 7% jaggery and 8% pulp was accepted by all the judges and therefore this treatment got higher score than other treatments.

Ubale^b *et al.* (2014) also studied utilization of jaggery in kulfi. The research project was conducted at Rajhans Dairy, Sangamner. The three levels of pulp of sapota 16, 25 and 40 % were used with three levels of jaggery *i.e.*, 7, 8 and 9 % to prepare the kulfi. In conclusion the protein and fat content decreased with levels of jaggery and fruit pulp in each product *i.e.*, Kulfi and the non-reducing sugar, reducing sugar, iron, ash, total solids contents were increased in end product with increase in level of both *i.e.*, jaggery and fruit pulp.

Shrivastav *et al.* (2016) had studied jaggery as the natural sweetener which is prepared by sugarcane juice. It is available in solid, liquid and powder form. It is also called as non-centrifugal sugar (NCS). The micronutrients that are present in jaggery have many nutritional and medicinal aspects like its anti-carcinogenic & antitoxic activity. Jaggery has proved itself better as compared to white sugar. Jaggery is known to produce heat and give instant energy to a human body. It is rich in important minerals (*viz.*, Calcium – 40-100 mg, Magnesium – 70-90 mg, Potassium – 10-56 mg, Phosphorous – 20-90 mg, Sodium – 19-30 mg, Iron – 10-13 mg, Manganese – 0.2-0.5 mg, Zinc – 0.2-0.4 mg, Copper – 0.1-0.9 mg, Chloride – 5.3 mg per 100g of jaggery), vitamins (*viz.*, Vitamin A – 3.8mg, Vitamin B₁ – 0.01mg, Vitamin B₂ – 0.06 mg, Vitamin B₅ – 0.01 mg, Vitamin B₆ – 0.01 mg, Vitamin C – 7.0 mg, Vitamin D₂ – 6.50 mg, Vitamin E – 111.30 mg, vitamin PP –

7.00 mg) and protein 280 mg per 100 g of jaggery, which can be made available to the masses to mitigate the problems of malnutrition and undernutrition. The micronutrients present in the jaggery possess antitoxic and anti-carcinogenic properties. It has moderate amount of calcium, phosphorous and zinc.

Mahalaxmi and Hemlatha. (2018) made an attempt to utilize jaggery in cookies. Flour was sieved with 0.5 % baking powder, fat (50g) and powdered sugar (60g). It was then blended and made to dough, sheeted for uniform thickness of 0.5mm, punched manually into circular shapes of 3mm diameter, baked at top temperature of 180°C and bottom temperature 150°C for 20 minutes, allowed to cool and evaluated. The most acceptable proportion of little millets to refined wheat flour cookies was further used to standardize optimum addition of jaggery. Cookies were evaluated for physical and organoleptic, characters. Standardization of jaggery based cookies was carried out by replacing sugar with non-organic or organic jaggery by 0, 25, 50, 75, 100, 125 and 150%.

Lamdande *et al.* (2018) studied the effect of replacement of sugar with jaggery on pasting properties of wheat flour. In order to utilize jaggery in place of sugar muffins were prepared by replacing 84% sugar with 42, 63 and 84% jaggery. Different levels of eggs namely 42, 63 and 84% were also tried for preparation of jaggery muffins. The results showed that muffins prepared with 84% each of jaggery and eggs had acceptable quality characteristics. The muffins with jaggery had lower pH, overall quality score and higher a_w than muffins with sugar. The muffins prepared using jaggery were softer than those prepared using sugar.

Ayare *et al.* (2020) studied preparation of basundi by replacing sugar with jaggery. The research was carried with a view of preparation of buffalo milk basundi with different concentrations *viz.*, 5, 6, 7 percent of chemically processed jaggery referred as T₁, T₂, T₃ respectively. Based on the panel's sensory assessment, basundi with 6% i.e.T₂ was chosen for further investigation. Storage study of basundi with T₂ treatment and control was performed using an analysis for nutritional as well as chemical composition. Use of 6% jaggery significantly maintained the sensory, nutritional and chemical characteristics of basundi more than the control.

Sonawane and Sonkamble (2020) studied the effect of jaggery powder on the sensory and nutritional quality of shrikhand in order to manage and control eating calorie-rich food like sugar increases the risk of diabetes. Shrikhand was prepared by replacing 45% sugar with three levels of jaggery i.e 31, 41, and 51% jaggery. Jaggery powder was used and study was conducted in completely randomized design with three replications. The effect of all treated samples and their interaction was studied on the sensory quality of shrikhand. The study showed that shrikhand (S₂) prepared with 41% jaggery powder had more acceptable quality characteristics among all the experimental samples.

2.6 Utilization of Skim Milk Powder in Dairy Products

Shinde (1995) worked on utilization of Skim milk powder for preparation of shrikhand and found that it contains total solids 53.53 percent, moisture 46.46 percent, fat 8.76 percent, protein 6.27 percent, sucrose 38.66 percent, acidity 1.005 percent and ash 0.896 percent.

Brahmapurkar *et al.* (2007) utilized skim milk powder for preparation of *Shrikhandwadi*. The fortification of SMP in chakka improved the texture of *Shrikhandwadi*. The moisture content of shrikhandwadi reduced to 8.3% from 9.4% on fortification with 10% SMP. The total solids, protein and total carbohydrate content increased from 90.6, 7.7 and 69.1 to 91.7, 8.4 and 69.7% respectively.

Akal and Yetisemiyen (2016) worked on utilization of skim milk powder in fermented cream. The addition of SMP affected the titrable acidity and tyrosine values of fermented cream. Although the addition of SMP did not have significant variations in total solids, fat, pH value, viscosity, acid number and diacetyl values on storage. Fermented cream added with 2% SMP got the top score for sensory evaluation.

Toradmal (2017) utilized SMP for standardization of *Shrikhandwadi* enriched with whey protein concentrate. The SMP was added at three levels i.e., 5, 10 and 15% at two different stages i.e., before heating stage of chakka and at after heating stage of chakka. SMP added @ 10% got the highest score for sensory attributes at after heating stage of chakka.

2.7 Drying Study of Various Products

Sakin-Yilmazer *et al.* (2007) studied on freeze drying of yoghurt powder added with chestnut puree in ratios of 5, 10, and 15% by weight. During freeze drying process mass lost, water activity and moisture present in samples was determined. The samples with thickness of 5 mm were frozen in petri plates in an air blast freezer and freeze dried at minimal vacuum chamber pressure reached by the freeze drier apparatus at condenser temperature of -50°C.

Divya and Babu (2015) worked on production of dahi powder using vacuum tray drier. Dahi prepared by traditional method was subjected to a vacuum of 580 mm Hg (temperature inside the chamber was 40°C) for a period of 18 hours. The final product was analyzed for its physical, microbial, chemical, and sensory characteristics and it had 6.7% moisture.

Hani *et al.* (2014) studied the effect of drying on the physical characteristics of dehydrated watermelon rind candies which were prepared using osmotic dehydration process. The candies were dried at 50 and 60°C for 8, 14 and 20 h. It was reported that the drying temperature and time significantly affected the moisture content and water activity of the dehydrated candies. The hardness and stickiness of the watermelon rind candy slightly increased with increasing drying time at 50 and 60°C. Watermelon rind candy that was dehydrated at 50°C for 14 h was most preferable as it received highest score for texture, taste and overall acceptability.

Toradmal (2017) studied the effect of temperature-time combination for drying on sensory qualities of *Shrikhandwadi*. The *Shrikhandwadi* sample was dried at 40, 50 and 60°C for 15 and 30 minutes. The maximum score was obtained by sample dried at 40°C for 30 minutes. It was reported that the score for product decreased as the temperature and time increased beyond 40°C for 30 minutes.

Patil and Gawande (2018) studied on drying of amla candy in solar tunnel greenhouse dryer. The quality of solar dried amla candy was far better and could fetch around 20% extra price than that of open/mechanized drying.

3. MATERIAL AND METHODOLOGY

The study entitled 'Preparation of goat milk *Shrikhandwadi* sweetened by jaggery' was conducted in the laboratory of Division of Animal Husbandry and Dairy Science, Rajarshree Chhatrapati Shahu Maharaj (RCSM) College of Agriculture, Kolhapur. The material used and methodology adopted during the entire period of investigation is presented as below under suitable headings.

3.1 Materials:

3.1.1 Milk: Fresh goat milk was procured from Dairy Farm, RCSM College of Agriculture, Kolhapur.

3.1.2 Starter culture: Starter culture LF-40 was procured from National Collection of Dairy Cultures (NCDC).

3.1.3 Jaggery: Jaggery powder was procured from local market of Kolhapur city.

3.1.4 Skimmed milk powder: Skimmed milk powder (SMP) was procured from Kolhapur district milk producer union (Gokul).

3.1.5 Karahi: An iron *karahi* was used for preparation of *Shrikhandwadi*.

3.1.6 Stirrer: Long handled stirrer with flattened end made up of mild steel was used for stirring - cum scraping the milk during preparation of *Shrikhandwadi*.

3.1.7 Incubator: Metalab Ltd. make incubator was used for incubation of milk inoculated with starter culture.

3.1.8 Blender: Blender was used for blending the *Shrikhandwadi* mix.

3.1.9 Cabinet Air Dryer: Vidha Life Sciences Pvt. Ltd make Cabinet air dryer was used for drying of *Shrikhandwadi*.

3.1.10 Food Grinder cum Mixer: Jyoti make food grinder cum mixer was used during course of investigation for grinding of sugar.

3.1.11 Hot Water Bath: Electrical hot water bath was used throughout the study period to determine chemical parameters of *Shrikhandwadi*.

3.1.1 Digital Thermometer: Digital thermometer having a convenient digital display was used for measuring temperature during preparation of *Shrikhandwadi*.

3.2 Chemicals:

All the chemicals required for the analytical work were used of Analytical Reagent (AR) or Guaranteed Reagent (GR) grade manufactured by Qualigens fine chemicals Ltd.

3.3 Methodology:

3.3.1 Study of Market Samples of *Shrikhandwadi*

A preliminary study was carried out to know the sensory, physico-chemical, colour value, texture profile and physical attributes of *Shrikhandwadi* from Kolhapur, Pune, Ratnagiri and Sindhudurg and the samples were coded as M₁, M₂, M₃ and M₄.

3.3.2 Preparation of *Shrikhandwadi*:

Shrikhandwadi was prepared as per the procedure reported by Brahampurkar *et al.*, (2007) with certain modification (Fig. 1). Initially goat milk was standardized at 3.5 percent fat, which was then heated and cooled to room temperature. The milk was then inoculated with starter culture @1.5 per cent of milk and then incubated at 24-26°C for 10 to 12 h. The obtained dahi was then transferred to muslin cloth and hung for 10-12 h to remove free whey. The semi-solid mass obtained thus called as “chakka”. The chakka was mixed with 15% SMP, sugar/jaggery, at different levels followed by blending cum mixing in mixture to have smooth and homogenous consistency. The homogeneous mass was then transferred in non-sticky pan and heated (90-100°C) to get pasty consistency followed by spreading in a tray in a thin layer. The product was cut into circular shape and allowed to dry at room temperature for 8 h.

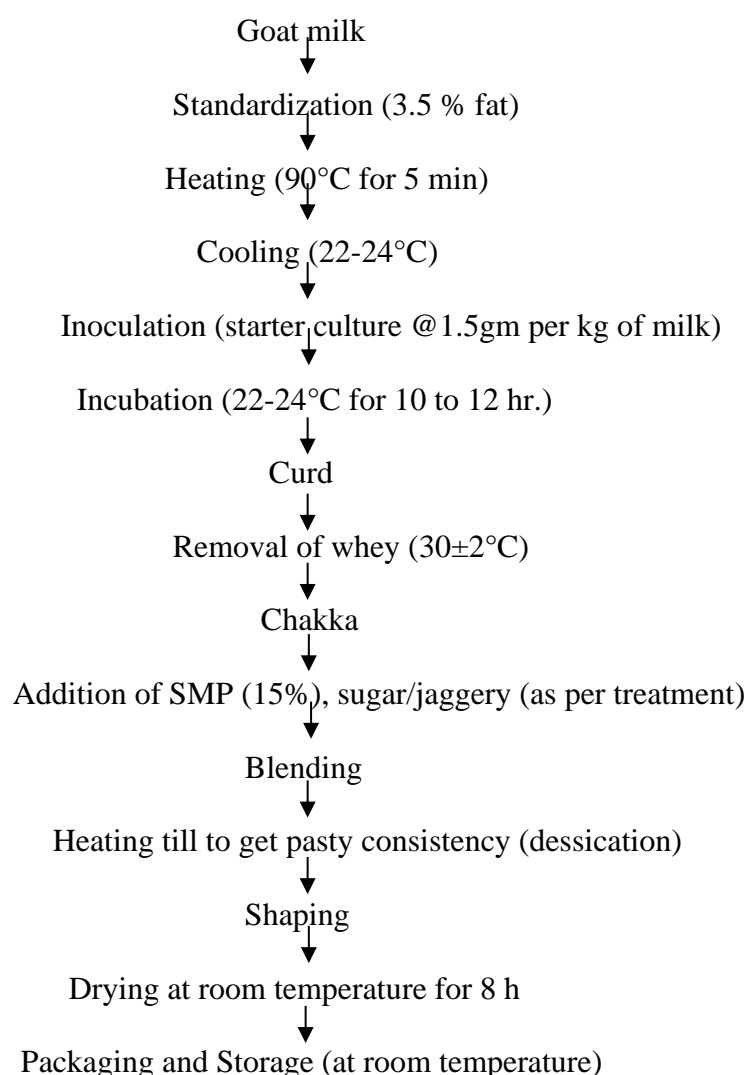


Fig 1: Flow diagram for preparation of *Shrikhandwadi* sweetened by jaggery

3.3.3 Optimization of the Level of Jaggery in *Shrikhandwadi*:

The level of jaggery was optimized by addition of jaggery at following levels of chakka. The level was decided on the basis of preliminary trial. The quantity of SMP was kept constant at

15 per cent of chakka in all treatments. Control *Shrikhandwadi* sample was made by incorporating sugar @ 125% of chakka. The treatments were

J₀: *Shrikhandwadi* incorporated with 125% sugar of chakka

J₁: *Shrikhandwadi* incorporated with 25% jaggery and 100% sugar of chakka.

J₂: *Shrikhandwadi* incorporated with 50% jaggery and 75% sugar of chakka.

J₃: *Shrikhandwadi* incorporated with 75% jaggery and 50% sugar of chakka.

J₄: *Shrikhandwadi* incorporated with 100% jaggery and 25% sugar of chakka.

J₅: *Shrikhandwadi* incorporated with 125% jaggery and 0% sugar of chakka.

The above treatments were replicated 4 times. The product was evaluated for sensory and physico-chemical qualities and the best level of jaggery was optimized on the basis of sensory qualities of *Shrikhandwadi*.

3.3.4 Drying Study of *Shrikhandwadi*:

The *Shrikhandwadi* prepared by above optimized formulations was kept in Cabinet air dryer for drying at 40, 50, and 60°C for 15 and 30 minutes.

T₁: *Shrikhandwadi* kept at 40 °C for 15 min.

T₂: *Shrikhandwadi* kept at 40 °C for 30 min.

T₃: *Shrikhandwadi* kept at 50°C for 15 min.

T₄: *Shrikhandwadi* kept at 50°C for 30 min.

T₅: *Shrikhandwadi* kept at 60°C for 15 min.

T₆: *Shrikhandwadi* kept at 60°C for 30 min.

The above treatments were replicated 4 times. The best level of jaggery was optimized on the basis of sensory qualities of *Shrikhandwadi*.

3.4 Analytical Methods:

3.4.1 Physico-chemical Analysis of Goat Milk Chakka

The fat, protein, lactose, ash and moisture with acidity of goat milk chakka was determined as per the procedure of FSSAI, 2015

3.4.2 Physico-chemical Analysis of *Shrikhandwadi*

3.4.2.1 Fat:

The fat content was determined as per procedure described in Laboratory Manual of FSSAI (2015) with certain modification.

10 g of sample was weighed in 10 mL warm water, and was introduced into mojonnier fat extraction tube, followed by addition of 25 mL peroxide free ethyl ether. The tube was closed tightly and the contents were vigorously shaken for a minute. Later, tube was opened and 25 mL of petroleum ether was added in it, then the tube was shaken for 30 seconds again and allowed to

stand in undisturbed condition for 30 minutes. The supernatant was decanted into previously dried, cooled and weighed dish. The extraction and decantation operation were carried out two times by use of 25 ml peroxide free ethyl ether and 25 ml petroleum ether. The solvent was dried on hot plate, after complete dehydration; dish was placed in oven at 100°C for 60 min. The dish was cooled and the weight was recorded. The percent fat was measured by using following formula.

$$\text{Fat \%} = \frac{M_1 \times 100}{M_2 \times (100 - M)}$$

Where,

M_1 = Weight of fat in g

M_2 = Weight of sample taken in g

M = Moisture % in sample.

3.4.2.2 Protein

Determined by the procedure as suggested in Laboratory Manual of FSSAI (2015). Total protein was determined by the Semi-Micro Kjeldahl method using the Kjel-plus Digestion System and the Kjel-plus Semi-Automatic Distillation System as follows:

In the digestion tube, take out 1.0 g accurately weighed sample, and then add 2.4 g digestion mixture (potassium sulfate: copper sulfate: selenium dioxide: 1:0.1:0.1). 10 ml of concentrated sulfuric acid was poured to the contents of the tube. Then transfer the tube to the digestion block and digest for about 30 minutes at a final temperature of 350°C.

The cooled and digested contents are loaded into the Kjel-plus distillation unit and after the unit is "ready". A fixed volume of alkali (20 mL 40% sodium hydroxide) is automatically added to the sample. The distillation time is fixed at 6 min. The released ammonia is condensed and collected in 25 ml of saturated boric acid solution, which contains three drops of mixed indicator (equal volume of methyl red saturated solution and 0.1% methylene blue solution, both at 95% (v/v) made in ethanol). The distillate in boric acid was titrated with 0.1 N sulfuric acid. Run a reagent blank simultaneously with all the above chemicals except the sample, and subtract its reading from the experimental reading. Use the formula to calculate the percentage of total nitrogen:

$$\text{Total protein (\%)} = \frac{1.4007 \times (\text{Burette reading} - \text{Blank reading}) \times N}{W}$$

Where,

W = Weight of the sample in g.

N = Normality of the standard sulfuric acid.

For converting the values of total nitrogen into per cent total protein, the values were multiplied by a factor of 6.38 for milk protein.

3.4.2.3 Reducing sugar:

Reducing and non-reducing sugar of the *Shrikhandwadi* sample was determined by method described in IS: 6287 (Part-I), 2000.

In a 250 ml conical flask, 5 g of *Shrikhandwadi* sample was transferred and diluted with 150 mL distilled lukewarm water. The content was mixed and precipitated with 5 mL zinc acetate solution. After 15 min, the excess zinc acetate solution was precipitated, followed by 5 mL potassium ferrocyanide solution and the mixture was filtered using Whatman No.1 filter paper in 250 mL volumetric flask. The precipitate on the filter paper were collected in the volumetric flask. After cooling the flask make up to 200 mL of distilled water.

The sugar solution filtrate, was filled in the burette and titrated against 5 mL each of Fehling's A and Fehling's B solutions using methylene blue as an indicator. The titration was done over a flame till a clear brick red precipitate was observed. The readings were then used to calculate lactose content of the product is as follows:

$$\text{Reducing Sugars \% by mass} = \frac{\text{Dilution} \times \text{Factor of Fehling (g)}}{\text{Weight of sample} \times \text{Titrate value}} \times 100$$

3.4.2.4 Non-reducing sugar:

Ten ml of filtered solution (prepared as per described in section 3.4.2.3) in a conical flask was hydrolyzed using 1.5 ml of concentrated hydrochloric acid in a boiling water bath at 60-70°C for 10 minutes. It was cooled immediately and the contents were neutralized with 30 % sodium hydroxide (m/v) solution. The content was quantitatively transferred to a 250 mL volumetric flask and the final volume was made to 100 mL. Then this solution was used for titration against to boiling 5 mL each of Fehling's solutions as usual & from the average titration values, the percentage of sucrose was determined as under:

$$\text{Non-reducing Sugar \% by mass} = \frac{(\text{O} - \text{RM}) \times 0.95}{\text{M}}$$

Where,

O = The value corresponding to titrate in the manual

R = Reducing sugars, percent by mass

M = Mass of the original material taken for the test in g

3.4.2.5 Ash:

Ash was measured as per the method IS: 1479 (Part 2, 1961) for milk with slight modification as under

2 g of sample (*Shrikhandwadi*) was weighed into a silica dish which was ignited on a laboratory Bunsen burner. The final incineration was done in a muffle furnace at not more than 550°C for 2 hours until the ash was carbon free, cooled into desiccator and weighed. Constant weight of ash has reached when the difference in two consecutive weighing after repeating ignition was less than 0.5g. The ash content was expressed as percent of the gross product.

$$\% \text{ Total ash} = \frac{W_1 - W_2}{W}$$

Where,

W_1 = Weight of silica dish

W_2 = Weight of silica dish + total ash (after final ignition)

W = Weight of sample taken for test

3.4.2.6: Moisture

Moisture content of *Shrikhandwadi* was analyzed as per the procedure described in FSSAI (2015).

Shrikhandwadi sample of about 2 g was weighed in a dish that was previously dried and weighed. The dish containing sample was heated in the electric oven, temperature of which was maintained at $102 \pm 10^\circ\text{C}$ for about 2 h. Later the dish was cooled in desiccator and weight was recorded with the cover on the dish. This process of drying, cooling and weighing at an interval of 30 minutes was repeated till the difference in the two consecutive weighing's was less than 1 mg and the lowest weight was recorded. The per cent moisture in sample was calculated by using formula:

$$\text{Moisture (\% by weight)} = \frac{100 (W_1 - W_2)}{W_1 - W}$$

Where,

W_1 = Weight of the dish in g along with sample prior to drying

W_2 = Weight of the dish in g along with sample after drying

W = Weight in gm of the empty dish.

3.4.2.7 Titratable acidity (% LA):

It was determined as per the procedure described in Laboratory Manual of FSSAI (2015) with certain modification. Accurately 10 gm of *Shrikhandwadi* sample was weighed in a suitable dish. 30 mL of warm water was added followed by addition of 1 mL of phenolphthalein indicator. The contents were shaken well and titrated against standard NaOH solution. The titration was

completed in 20 seconds. Similarly, a blank was run by taking 30 ml of water in another dish for comparison of colour.

Calculation:

$$\text{Titrateable acidity as Lactic acid (\%)} = \frac{9 \times N \times V}{W}$$

Where,

V= Volume of standard NaOH required for titration

N= Normality of standard NaOH solution

W= weight of the sample taken for the test

3.4.2.8 Solubility:

It is expected that a piece of *Shrikhandwadi* must take optimum time to become soluble while eating. Hence to know the time required for solubilizing, a piece of *Shrikhandwadi* sample was placed in 150 mL glass beaker having 100 mL distilled water. The beaker was kept in hot water bath at 37°C. The time in minutes required for complete solubilizing of *Shrikhandwadi* was recorded by visual observation. (Toradmal, 2017)

3.4.3. Determination of Hunter Colour Value:

Colour measurements was conducted using Colour Flex (M/s Hunter Associates Laboratory, Inc., Reston VA, US) colour measurement system that was equipped with dual beam xenon flash lamp and universal software. The instrument was calibrated before measurements with standard black, white and green tile as per the prescription of the supplier. The results were presented as L*, a* and b*. It is a 3-D method for colour presentation in which L* represents the lightness of colour, which equals 0 for black and 100 for white. a* shows the extent of red (0 to 60) or green (0 to -60) whereas b* represents yellowness (0 to 60) or blueness (0 to - 60).

3.4.4 Determination of Texture Profile of *Shrikhandwadi*

The Texture Profile Analysis of *Shrikhandwadi* was conducted using Texture Analyzer (model TAHDi, Stable Micro Systems Ltd.) at room temperature. The conditions set in the Texture Analyzer for measuring textural properties included: pre-test speed 1 mm/sec, test speed 5 mm/sec, post-test speed 5 mm/sec, strain 50%, time 5 sec., trigger force 5.

3.4.5 Sensory Evaluation of *Shrikhandwadi*:

The acceptability of *Shrikhandwadi* was assessed at Division of Animal Husbandry and Dairy Science. The flavour, colour and appearance, body and texture and overall acceptability was assessed by using 9 – point Hedonic scale as per Amerine *et al.* 1965 as shown in Annexure I.

3.4.6 Statistical Analysis:

The data obtained was analysed using Completely Randomized Design (CRD) as per Snedecor and Cochran (1994). Students' 't' test was used for the comparison of market sample and experimental sample.

3.5 Requirement of Facilities and their Availability:

All the facilities required to carry out the research work available at Division of Animal Husbandry and Dairy Science, RCSM College of Agriculture Kolhapur and Department of Food Technology, Shivaji University Kolhapur were utilized.

4. RESULT AND DISCUSSION

Fermented milk products have been a crucial component of nutritional diet and the important milk products (fermented) include dahi, lassi, yoghurt and shrikhand. Shrikhand is a semi-soft, sweetish sour, whole milk product obtained from fermented curd (Kulkarni *et al.*,2006). It is popular all over the country and recently due to globalization it has gained demand in few other countries. However, owing to high moisture the shelf life of shrikhand is limited at ambient temperature. Therefore, the partial evaporation of moisture by converting into solid confection (*Shrikhandwadi*) can be excellent means to extend the shelf life of shrikhand.

The present investigation was aimed at partially evaporating the moisture from goat milk shrikhand with addition of jaggery/sugar, SMP to obtain *Shrikhandwadi* with desirable sensory and physico-chemical characteristics. The prepared samples were dried at various temperature-time combination. The results of the study are tabulated and discussed under following headings.

4.1 Study of market sample of *Shrikhandwadi*

4.2 Physico-chemical analysis of goat milk chakka

4.3 Effect of level of jaggery replacement to sugar on sensory, physico-chemical, texture and Hunter colour value of *Shrikhandwadi*

4.4 Effect of temperature-time combination during drying on sensory attributes of *Shrikhandwadi*

4.5 Optimized flow diagram for preparation of *Shrikhandwadi* sweetened by sugar/jaggery

4.6 Physico-chemical composition of optimized *Shrikhandwadi*

4.7 Comparison of prepared market *Shrikhandwadi* sample with prepared sample

4.1 Study of Market Sample of *Shrikhandwadi*

A preliminary study was carried out to evaluate the sensory, chemical, texture profile, colour value and physical measurements of market sample of *Shrikhandwadi*. Accordingly, four samples were collected from Kolhapur, Pune, Ratnagiri and Sindhudurg market and were coded as M₁, M₂, M₃ and M₄.

4.1.1 Sensory Analysis of Market *Shrikhandwadi* Sample

The *Shrikhandwadi* samples thus obtained from various markets was analysed in terms of colour and appearance, flavour, body and texture and overall acceptability.

4.1.1.1 Colour and appearance

Colour and appearance is considered as one of the important consumer quality judging parameters in selection of dairy product. The colour and appearance of *Shrikhandwadi* is expected to be slight dry in appearance with light to brown even colour distribution.

From Table 1, it is observed that the colour and appearance score for different market samples varied significantly. The score for colour and appearance for M₁, M₂, M₃ and M₄ were 7.00 ± 0.05 , 7.25 ± 0.04 , 7.30 ± 0.04 and 6.70 ± 0.04 respectively. Sample M_{3s} received the highest score which was light orange in colour with slight dry appearance and was liked by the judges.

The lowest score for colour and appearance was obtained by sample M₄ due to its dark orange colour, which was not found to be impressive by the judges. Upon observing the samples for colour and appearance it was observed that most of the samples were coloured with synthetic colour and it was easy removed on rubbing the sample.

Kamble *et al.* (2015) reported that the addition of synthetic colour was more common in fig burfi samples collected from different halwais in Maharashtra state. Wide variation in colour and flavour of burfi sold commercially in Indian market is supported by Sarkar *et al.* (2001).

Table 1 Sensory score of market samples

Market sample	Sensory attributes			
	Colour and appearance	Flavour	Body and texture	Overall acceptability
M ₁	7.00 ^b ± 0.05	7.10 ^b ± 0.05	7.35 ^b ± 0.04	7.15 ^b ± 0.05
M ₂	7.25 ^a ± 0.04	6.80 ^c ± 0.04	6.50 ^d ± 0.03	6.85 ^c ± 0.04
M ₃	7.30 ^a ± 0.04	7.45 ^a ± 0.03	7.90 ^a ± 0.06	7.55 ^a ± 0.06
M ₄	6.70 ^c ± 0.04	6.90 ^c ± 0.04	6.70 ^c ± 0.06	6.70 ^c ± 0.05
CD	0.13	0.17	0.13	0.15
Sem	0.04	0.04	0.04	0.05

*Mean ± SE (n=4) within column followed by different superscript differ significantly (p<0.05) from each other

4.1.1.2 Flavour

Flavour is an important attribute in judging of dairy product and its acceptability by the consumers. The flavour of *Shrikhandwadi* is expected to be slight sour with appreciable sweet taste. From Table 1, it can be observed that the score for flavour of market samples ranged from 6.80 ± 0.04 to 7.45 ± 0.03. The highest score for flavour of *Shrikhandwadi* was received by sample M₃ which might be due to its expected slight sour and appreciable sweet taste. The lowest score was received by sample M₂, as it was much sweeter in taste and was not liked by the judges. Sample M₁ was observed to have vanilla flavour which clearly indicated that artificial flavour was added by the producer in *Shrikhandwadi*. Kamble *et al.* (2015) reported that only few (4.17%) *halwais* added synthetic flavour in fig burfi. Kumar *et al.* (2016) revealed that the differences among the flavour score of market samples were highly significant (p<0.01).

4.1.1.3 Body and texture

It is desirable that the *Shrikhandwadi* sample should have expected hardness and it should not form powder on breaking. It is expected to break into pieces on biting. Table 1 depicts the score for body and texture for the market samples. The score for body and texture of *Shrikhandwadi* for M₁, M₂, M₃ and M₄ was 7.35 ± 0.04, 6.5 ± 0.03, 7.90 ± 0.06 and 6.70 ± 0.06 respectively. Sample M₃ received highest score for body and texture as it had expected hardness. The lowest score was received by sample M₂ as it formed powder on breaking.

Kumar *et al.* (2016) revealed that the differences among the body and texture score of market samples were highly significant (p<0.01).

4.1.1.4 Overall acceptability

From Table 1, it can be observed that the score of overall acceptability of *Shrikhandwadi* differed significantly. The score for overall acceptability ranged from 6.7 ± 0.05 to 7.55 ± 0.06 . The highest score was obtained by sample M_3 in response to its relatively higher score for colour and appearance, flavour and body and texture. The lowest score was received by sample M_4 . The market samples on the basis of score for overall acceptability can be arranged as $M_3 > M_1 > M_2 > M_4$. Hence the sample M_3 was found to be superior on the basis of sensory attributes among all other market samples evaluated.

Variation in ingredients, their proportion and processing conditions affect the quality of burfi (Chetana *et al.*, 2010) which might affect the overall acceptability of different market samples. Kumar *et al.* (2016) reported that organoleptic evaluation showed that all the sensory attributes of market milk cake varied significantly from shop to shop.

4.1.2 Chemical Composition of Market Sample

Table 2 Chemical composition of market sample

Market sample	Chemical composition					
	Moisture (%)	Fat (%)	Protein (%)	Non reducing sugar (%)	Ash (%)	Acidity (%LA)
M_1	$4.31^d \pm 0.05$	$0.21^b \pm 0.04$	$1.12^b \pm 0.04$	$92.12^c \pm 0.04$	$1.24^a \pm 0.04$	$0.72^b \pm 0.02$
M_2	$4.78^c \pm 0.04$	$0.40^a \pm 0.03$	$0.12^c \pm 0.05$	$93.50^d \pm 0.03$	$1.20^a \pm 0.04$	$0.70^b \pm 0.05$
M_3	$5.20^b \pm 0.04$	$0.42^a \pm 0.02$	$2.25^a \pm 0.04$	$90.98^c \pm 0.04$	$1.15^a \pm 0.03$	$0.73^b \pm 0.05$
M_4	$5.80^a \pm 0.05$	$0.10^b \pm 0.04$	$0.20^c \pm 0.04$	$92.84^b \pm 0.04$	$1.06^b \pm 0.04$	$1.20^a \pm 0.04$
SEm	0.04	0.03	0.04	0.04	0.04	0.04
CD	0.15	0.11	0.15	0.13	0.13	0.15

*Mean \pm SE (n=4) within column followed by different superscript differ significantly ($p < 0.05$) from each other

From Table 2, it can be observed that the moisture content of market *Shrikhandwadi* samples ranged from 4.31 ± 0.05 to 5.80 ± 0.05 percent. The results depicted that the moisture content of samples varied from market to market. Banjare *et al.* (2015) reported that the moisture content of peda samples differed significantly ($p < 0.01$) and the variation in moisture content of peda samples might be mainly due to difference in method of manufacturing, extent of dessication, amount of sugar added and also difference in chemical composition of base material used.

The values for fat content of *Shrikhandwadi* samples M_1 , M_2 , M_3 and M_4 were 0.21 ± 0.04 , 0.40 ± 0.03 , 0.42 ± 0.02 and 0.10 ± 0.04 percent. The variation in fat content of market sample was significant ($p < 0.05$). The present results are in accordance with (Banjare *et al.*, 2015) who revealed the variation in fat content of peda samples.

Table 2 depicts that the values for protein content of *Shrikhandwadi* ranged from 0.12 ± 0.05 to 2.25 ± 0.04 percent. The variation in protein content of market samples M_1 , M_2 , M_3 and M_4 was found to be significant. ($p < 0.05$). The results are in line with (Banjare *et al.*, 2015) and

Kumar *et al.* (2016) who reported significant differences among market samples of peda and milk cake respectively.

The non-reducing sugar content of *Shrikhandwadi* samples M₁, M₂, M₃ and M₄ were 92.12 ± 0.04, 93.50 ± 0.03, 90.98 ± 0.04, and 92.84 ± 0.04 respectively percent. The highest value of non-reducing sugar was obtained for treatment M₂ and the lowest for treatment M₃. The non-reducing sugar content of the *Shrikhandwadi* samples was significantly different. Kumar *et al.* (2016) observed wide variations in non-reducing sugar content of market samples.

The ash content of the *Shrikhandwadi* samples ranged from 1.10 ± 0.04 to 1.20 ± 0.04 percent. The M₂ sample contained highest amount of ash as compared to other samples. Sample M₄ contained lowest amount of ash. The results are in line with Kumar *et al.* (2016) who observed significant differences in ash content of milk cake market samples.

The values for acidity of samples M₁, M₂, M₃ and M₄ were 0.73 ± 0.05, 0.70 ± 0.05, 0.72 ± 0.02 and 1.20 ± 0.04 per cent respectively. The acidity of market samples of *Shrikhandwadi* from different markets was found to be significantly (p<0.05) different. Banjare *et al.* (2015) observed significant differences in market sample of peda and reported that the significant differences in acidity might be due to use of milk either with different acidity or use of stored or fresh khoa for manufacture of peda and heat treatment employed during its manufacture.

4.1.3 Analysis of Texture profile of Market Sample

The market samples of *Shrikhandwadi* were analysed for textural properties *viz.* hardness, adhesiveness, springiness, cohesiveness, chewiness and guminess. The results thus obtained are compiled in Table 3. The hardness values of market samples varied significantly (p<0.05). the values for hardness ranged from 18412.08±0.03 to 18525.14±0.04. The values for adhesiveness ranged from -22±0.05 to -28 ± 0.03 g.sec. The variation in adhesiveness values was found to be non-significant.

Table 3 Texture profile of market sample

Market sample	Texture profile					
	Hardness (g)	Adhesiveness (g.sec)	Springiness (mm)	Cohesiveness (J/J)	Chewiness (N-mm)	Guminess (N)
M ₁	18525.14 ^a ±0.04	-28.23±0.03	0.26±0.04	0.17 ± 0.06	941.54±0.05	2520±0.03
M ₂	18112.08 ^d ±0.03	-22.54±0.05	0.18±0.06	0.12±0.03	949.31±0.04	2529±0.04
M ₃	18265.12 ^c ±0.04	-24.29±0.04	0.21 ± 0.05	0.13 ± 0.04	943.47±0.03	2527±0.04
M ₄	18494.10 ^b ±0.04	-26.23±0.05	0.23±0.04	0.15±0.04	943.23±0.04	2525±0.05
SEm	0.06	0.04	0.04	0.05	0.04	0.05
CD	0.19	NS	NS	NS	NS	NS

*Mean ± SE (n=4) within column followed by different superscript differ significantly (p<0.05)

from each other

The values for springiness for samples M₁, M₂, M₃ and M₄ were 0.26 ± 0.04 , 0.18 ± 0.06 , 0.21 ± 0.05 and 0.23 ± 0.04 respectively mm. The variation in springiness values was found to be non-significant. The values for cohesiveness ranged from 0.12 ± 0.03 to 0.17 ± 0.06 J/J and the variation among the samples was found to be non-significant.

The chewiness values for market samples M₁, M₂, M₃ and M₄ were 941.54 ± 0.05 , 949.31 ± 0.04 , 943.47 ± 0.03 and 943.23 ± 0.04 N-mm respectively. The values for gumminess ranged from 2520 ± 0.03 to 2529 ± 0.04 and the variation among them was found to be non-significant.

4.1.4 Hunter Colour Value of Market Sample

Table 4 depicts the Hunter colour values of samples M₁, M₂, M₃ and M₄. The L* values of market *Shrikhandwadi* samples ranged from 48.70 ± 0.12 to 76.21 ± 0.05 . The lower value of L* indicates that the product is tending towards darkness. The highest value for L* was found for sample M₃ indicating that the sample was relatively lighter than the other samples. The market *Shrikhandwadi* samples in increasing order of darkness were M₄>M₁>M₂>M₃.

The redness-greenness (a*) values for M₁, M₂, M₃ and M₄ were 10.72 ± 0.06 , 9.23 ± 0.05 , 8.87 ± 0.06 and 11.24 ± 0.06 respectively. The highest value for a* was found for sample M₃ and the lowest value was found for treatment M₄. The higher values of a* indicates that the colour of the product is tending towards redness. Table 4 shows that the values of a* for the market *Shrikhandwadi* samples were found to be significantly different. The variation in a* values might be due to the addition of synthetic colour in various proportion by the producers.

The yellowness-blueness (b*) values of market *Shrikhandwadi* samples ranged from 16.87 ± 0.05 to 25.12 ± 0.08 . The highest value of b* was recorded for sample M₄ and the lowest value for sample M₃. The higher b* value of indicates that the colour of product is tending towards yellowness.

Table 4 Hunter colour value of market sample

Market sample	Colour value		
	L*	a*	b*
M ₁	$64.36^c \pm 0.17$	$10.72^b \pm 0.06$	$18.67^b \pm 0.04$
M ₂	$66.43^b \pm 0.09$	$9.23^c \pm 0.05$	$17.54^c \pm 0.10$
M ₃	$76.21^a \pm 0.05$	$8.87^d \pm 0.06$	$16.87^d \pm 0.05$
M ₄	$48.70^d \pm 0.12$	$11.24^a \pm 0.06$	$25.12^a \pm 0.08$
SEm	0.11	0.06	0.07
CD	0.34	0.19	0.22

*Mean \pm SE (n=4) within column followed by different superscript differ significantly (p<0.05) from each other

4.1.5 Physical Attributes of Market Sample

The collected market *Shrikhandwadi* samples were analysed for physical attributes viz. weight, diameter and thickness of sample. The diameter and thickness of sample were measured using Vernier caliper. The data thus obtained is compiled in Table 5. The weight of market samples M₁, M₂, M₃ and M₄ were 1.28 ± 0.03 , 1.25 ± 0.04 , 1.35 ± 0.04 and 1.38 ± 0.04 g respectively. The highest weight was recorded for sample M₄ and sample M₂ was comparatively lighter in weight in comparison to other samples.

Table 5 Physical attributes of market sample (single piece of *Shrikhandwadi*)

Market sample	Physical attributes			
	Wt. of sample (g)	Diameter (mm)	Thickness (mm)	Solubility (min)
M ₁	$1.28^a \pm 0.03$	$17.71^b \pm 0.04$	$4.20^b \pm 0.03$	$70^b \pm 0.05$
M ₂	$1.25^b \pm 0.04$	$16.97^c \pm 0.03$	$4.24^a \pm 0.04$	$68^c \pm 0.05$
M ₃	$1.35^a \pm 0.04$	$17.92^{a\pm} \pm 0.04$	$4.25^a \pm 0.04$	$65^d \pm 0.04$
M ₄	$1.38^a \pm 0.04$	$17.91^{a\pm} \pm 0.04$	$4.30^a \pm 0.04$	$73^a \pm 0.05$
SEm	0.04	0.05	0.04	0.05
CD	0.13	0.14	0.13	0.17

*Mean \pm SE (n=4) within column followed by different superscript differ significantly ($p < 0.05$) from each other

The values for diameter of market *Shrikhandwadi* samples ranged from 16.97 ± 0.03 to 17.92 ± 0.04 . The values for diameter of samples M₁, M₂, M₃ and M₄ were found to be significantly ($p < 0.05$) different. The thickness of market samples ranged from 4.20 ± 0.03 to 4.30 ± 0.04 mm. The values for thickness of market sample M₂, M₃ and M₄ were significantly at par with each other. The highest value was recorded for sample M₄ and the lowest value for sample M₂.

The time required for solubilizing a piece of *Shrikhandwadi* sample ranged from 65 ± 0.04 to 73 ± 0.05 min. Sample M₁ required highest time for solubilizing. The lowest time was required by sample M₄ indicating that it had highest solubility. The difference in solubility might be due to difference in ingredients used by different producers.

4.2 Physico-Chemical Properties of Goat Milk Chakka

The chakka was prepared from goat milk and analysed for total solids, fat, protein, lactose, ash and acidity. The data is compiled and presented in Table 6. The data thus indicates that the chakka used in present investigation had optimum chemical constituents. The percent total solids, fat, protein, lactose, ash and acidity were 24.41 ± 0.17 , 11.13 ± 0.07 , 10.23 ± 0.15 , 2.06 ± 0.06 , 1.0 ± 0.20 and 1.7 ± 0.05 respectively.

Patil *et al.* (1982) reported the composition of goat milk chakka and their values are in the range of present findings, they reported goat milk chakka had total solids 28.51%, fat 11.94%, acidity 1.34% LA, curd tension 21.42%, moisture 71.48%.

Agnihotri and Pal (1996) prepared chakka from Barberi goat milk and reported that goat milk chakka contains 24.18% TS and 47.94% yield of chakka having pH 4.09 and titratable acidity 1.6% LA and these observations were close to the recorded values in present investigation.

Table 6 Physico-chemical analysis of goat milk chakka

Sr no.	Constituents (%)	Mean values
1.	Total solids	24.41 ± 0.17
2.	Fat	11.13 ± 0.07
3.	Protein	10.23 ± 0.15
4.	Lactose	2.06 ± 0.07
5.	Ash	1.0 ± 0.20
6.	Acidity	1.7 ± 0.05

*Mean ± SE of four replications

However, Sindhu *et al.* (2000) reported 31.61% TS in buffalo milk chakka and these results might be due to more TS present in buffalo milk than goat milk.

4.3 Effect of Level of Jaggery Replacement to Sugar on Sensory, Physico-chemical, Texture and Hunter Colour Value of *Shrikhandwadi*

To know the effect of level of replacement of jaggery to sugar in the preparation of *Shrikhandwadi*, the control sample sugar was prepared by addition of sugar (J₀) @ 125% of chakka. The other treatments included J₁ (100% sugar and 25% jaggery), J₂ (75% sugar and 50% jaggery), J₃ (50% sugar and 75% jaggery), J₄ (25% sugar and 100% jaggery), J₅ (125% jaggery). The obtained product was evaluated for sensory, physico-chemical properties, texture properties and instrumental colour values and the results thus obtained are presented under following subheadings.

4.3.1 Effect of Level of Jaggery Replacement to Sugar on Sensory Attributes of *Shrikhandwadi*

The above products were evaluated for sensory attributes *viz.* colour and appearance, flavour, body and texture and overall acceptability.

4.3.1.1 Effect on colour and appearance score of *Shrikhandwadi*

Colour and appearance is considered as one of the important consumer quality judging parameters in selection of dairy product. The colour and appearance of *Shrikhandwadi* is expected to be as slight dry appearance with even colour distribution.

From Table 7 and Fig. 3, it is clear that the colour and appearance score of *Shrikhandwadi* was significantly ($p < 0.05$) affected by the replacement level of jaggery. Upon 25% replacement of jaggery (J₁) a significant improvement in colour and appearance score was recorded over control sample. The score for colour and appearance increased as the level of jaggery increased upto 50 per cent replacement and later the score decreased. The highest score (8.31 ± 0.06) was obtained by J₂ product. The product under treatment J₂ was found to be slight brownish with faint red tinges as reported by judges. Further it was found that upon 125% replacement of jaggery to sugar unexpected results were recorded and the score decreased to 6.38 ± 0.07 and which was significantly lowest one. Upon increase in the level of jaggery replaced to sugar the colour became darker (brown) which did not appeal the judges.

Table 7 Effect of level of jaggery replacement to sugar level on colour and appearance score of *Shrikhandwadi*

Treatment	Replication				Mean score*
	I	II	III	IV	
J ₀	7.00	7.25	7.00	7.25	7.13 ^d ± 0.07
J ₁	7.85	8.00	7.90	8.00	7.94 ^b ± 0.03
J ₂	8.25	8.25	8.50	8.25	8.31 ^a ± 0.06
J ₃	8.15	8.15	8.25	8.50	8.26 ^a ± 0.08
J ₄	7.50	7.75	7.50	7.75	7.63 ^c ± 0.07
J ₅	6.25	6.50	6.25	6.50	6.38 ^e ± 0.07
	SEm				0.06
	CD (p<0.05)				0.20

*Mean ± SE (n=4) within column followed by different superscript differ significantly (p<0.05) from each other

The observed variation in colour and appearance due to the colour of jaggery which varies from dark brown or golden yellow to golden brown as reported by Hirpara *et al.* (2020). Similar observations for colour of jaggery was also reported by Deotale *et al.* (2019). Significant lowest (6.84) score for colour and appearance of shrikhand upon 51 per cent addition of jaggery was reported by Sonwane and Sonkamble (2020) which indicates the adverse effect of use of jaggery at higher concentration on colour and appearance of product.

The present findings are in accordance with the report of Dobariya *et al.* (2019) who reported that the ice cream containing sugar chikki looked more attractive than the one containing jaggery chikki. The slight migration of dark brown colour of jaggery from jaggery chikki to the nearby ice cream portions decreased the aesthetic appearance of such ice cream.

4.3.1.2. Effect on flavour score of *Shrikhandwadi*

Flavour of any food product is perhaps the most important and basic sensory perception that appeals the consumer and affects its acceptability. The flavour of *Shrikhandwadi* is expected to be mildly acidic, moderate sweet with slight cooked flavour.

Table 8 Effect of level of jaggery replacement to sugar on flavour of *Shrikhandwadi*

Treatment	Replication				Mean score*
	I	II	III	IV	
J ₀	7.20	7.25	7.25	7.00	7.18 ^c ± 0.05
J ₁	8.00	7.95	8.25	8.00	8.05 ^{ab} ± 0.06
J ₂	8.25	8.15	8.50	8.25	8.29 ^a ± 0.07
J ₃	7.75	8.00	7.75	8.00	7.88 ^b ± 0.07
J ₄	6.25	6.50	6.25	6.50	6.38 ^d ± 0.07
J ₅	5.25	5.50	5.25	5.50	5.38 ^e ± 0.07
	SEm				0.06
	CD (p<0.05)				0.21

*Mean ± SE (n=4) within column followed by different superscript differ significantly (p<0.05) from each other

From Table 8 and Fig 4, it is observed that the score for flavour of *Shrikhandwadi* ranged from 5.38 ± 0.07 to 8.29 ± 0.07. The flavour scores for J₀, J₁, J₂, J₃, J₄ and J₅ were 7.18 ± 0.05,

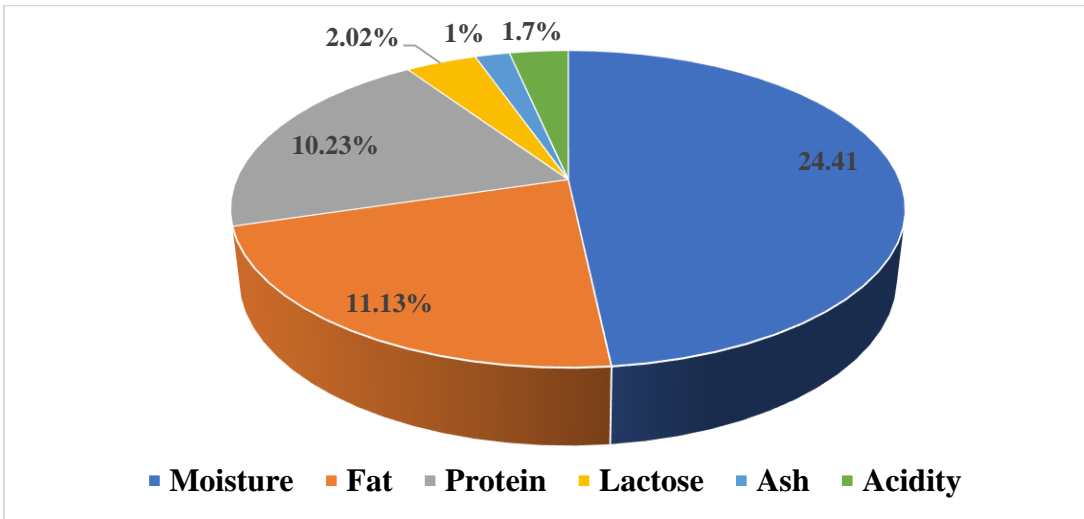


Fig 2: Physico-chemical composition of goat milk chakka

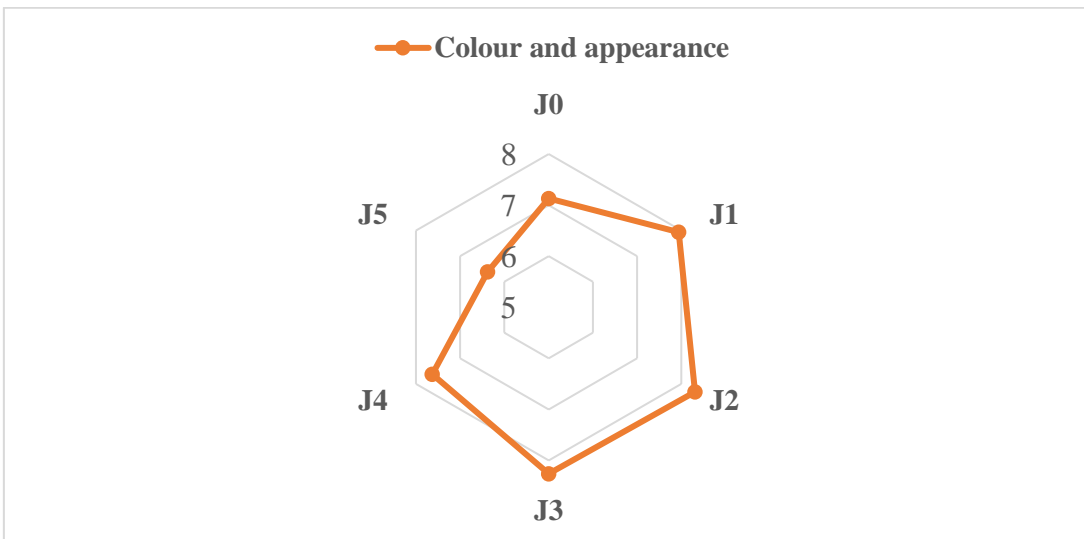


Fig 3: Effect of level of jaggery replacement to sugar on colour and appearance of Shrikhandwadi

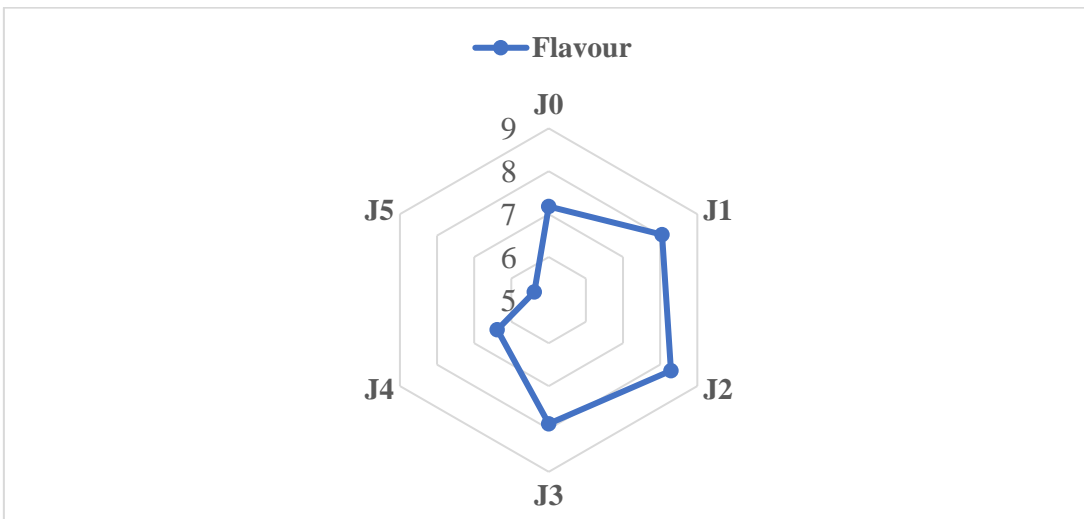


Fig 4: Effect of level of jaggery replacement to sugar on flavour of Shrikhandwadi

8.05 \pm 0.06, 8.29 \pm 0.07, 7.88 \pm 0.07, 6.38 \pm 0.07 and 5.38 \pm 0.07 respectively. The highest score was obtained by treatment J₂ and the lowest score obtained by J₅. The score for flavour of *Shrikhandwadi* increased up to treatment J₂ only and it was mild acidic, moderate sweet with slight jaggery flavour. At highest concentration of jaggery, the *Shrikhandwadi* flavour was observed to be sweeter with typical jaggery flavour which did not impress the judges. It might be due to sweet, wingy fragrance and flavour possessed by jaggery. Rao *et al* (2007) also reported that jaggery possess heady aroma and delicious flavour somewhere in between brown sugar and molasses which may affect the flavour attributes of other products. The finding is supported by Dobariya *et al.* (2019) who reported that ice cream containing caramel flavouring and sugar chikki had a clean caramel flavour while the product containing caramel flavouring and jaggery chikki imparted different sweetness profile and had slightly masking effect on caramel flavour.

4.3.1.3. Effect on body and texture score of *Shrikhandwadi*

Body and texture is an important attribute in judging of *Shrikhandwadi*. It is expected to eat it into pieces and upon biting a piece it should be cut with recognizable pressure. *Shrikhandwadi* sample should not form powder upon biting or swallowing and should break into pieces.

Table 9 Effect of level of jaggery replacement to sugar on body and texture of *Shrikhandwadi*

Treatment	Replication				Mean score*
	I	II	III	IV	
J ₀	7.25	7.50	7.25	7.50	7.38 ^a \pm 0.07
J ₁	7.15	7.25	7.00	7.25	7.16 ^a \pm 0.05
J ₂	6.85	6.00	6.75	6.00	6.90 ^b \pm 0.06
J ₃	6.75	6.50	6.50	6.75	6.63 ^c \pm 0.07
J ₄	6.25	6.50	6.25	6.50	6.38 ^d \pm 0.07
J ₅	5.10	5.25	5.10	5.50	5.24 ^e \pm 0.09
	SEm				0.07
	CD (p<0.05)				0.22

*Mean \pm SE (n=4) within column followed by different superscript differ significantly (p<0.05) from each other

From Table 9 and Fig 5, it can be observed that the score for body and texture ranged from 5.24 \pm 0.09 to 7.38 \pm 0.07. The highest score was obtained by treatment J₀ (*Shrikhandwadi* added with 125% sugar) and lowest score was obtained by J₅ (*Shrikhandwadi* added with 125% jaggery). The score of J₀ and J₁ were at par with each other. The score for body and texture was significantly (p<0.05) affected by the level of replacement of sugar by jaggery. The score for body and texture of *Shrikhandwadi* decreased from J₀ to J₅. Upon addition of jaggery, the product became softer,

sticky, slightly chewy and these characters were more pronounced with the increase in level of replacement of sugar by jaggery. It might be due to hygroscopic nature of jaggery which is imparted by the non-sucrose constituents such as glucose, fructose and protein, etc present in jaggery. Jaggery also contains 0.6 – 10% moisture as reported by (Rao *et al.*, 2007). Hirpara *et al.* (2020) reported that jaggery is semi-solid, softer than sugar and also amorphous in nature, which might be responsible for decreasing score for body and texture of the product as the product became softer than expected.

The findings are in line with that of Sonwane and Sonkamble (2020) who reported that shrikhand added with jaggery was semi-soft, softer than that added with sugar. Similar findings by Dobariya *et al* (2019) who reported that the body and texture score associated with ice cream containing jaggery chikki was due to prevalence of ‘gummy’ body. Even at the time of scooping, jaggery chikki based ice cream exhibited sticky body.

4.3.1.4 Effect on overall acceptability score of *Shrikhandwadi*

Overall acceptability of product is influenced by its colour and appearance, flavour and body and texture which contribute to its overall acceptability.

Table 10 Effect of level of jaggery replacement to sugar on overall acceptability of *Shrikhandwadi*

Treatment	Replication				
	I	II	III	IV	Mean score*
J ₀	7.15	7.33	7.16	7.25	7.22 ^c ±0.04
J ₁	7.66	8.06	7.71	7.75	7.80 ^a ±0.09
J ₂	7.78	7.80	7.91	7.83	7.83 ^a ±0.02
J ₃	7.55	7.55	7.50	7.75	7.59 ^b ±0.05
J ₄	6.67	6.91	6.60	6.91	6.77 ^d ±0.08
J ₅	5.53	5.75	5.50	5.83	5.65 ^e ±0.08
	SEm				0.06
	CD (p<0.05)				0.20

*Mean ± SE (n=4) within column followed by different superscript differ significantly (p<0.05) from each other

From Table 10 and Fig. 6, it can be observed that score for overall acceptability ranged from 5.65 ± 0.08 to 7.83 ± 0.02. The highest score was obtained by treatment J₂ and the lowest by J₅. The score for overall acceptability increased from J₀ to J₂ and then decreased upto treatment J₅. The decrease in overall acceptability score may be due to decrease in quality score in response to colour and appearance and flavour. The treatment J₂ recorded highest score (7.83± 0.02) and it was mildly acidic and had expected colour with comparatively good taste. The treatment J₅ with lowest score had too soft body and was acidic in flavour and the colour was dark brown which was not liked by the judges. Thus, the treatment added with 50% jaggery and 75% sugar was optimized for preparation of best quality *Shrikhandwadi* and was used in the further part of the experiment.

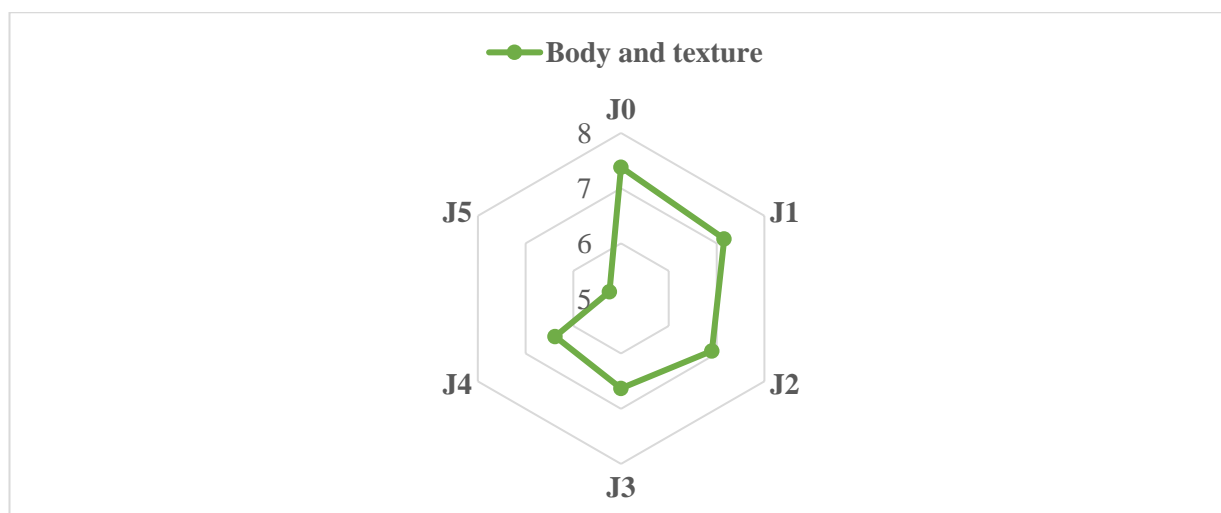


Fig 5: Effect of level of jaggery replacement to sugar on body and texture of *Shrikhandwadi*

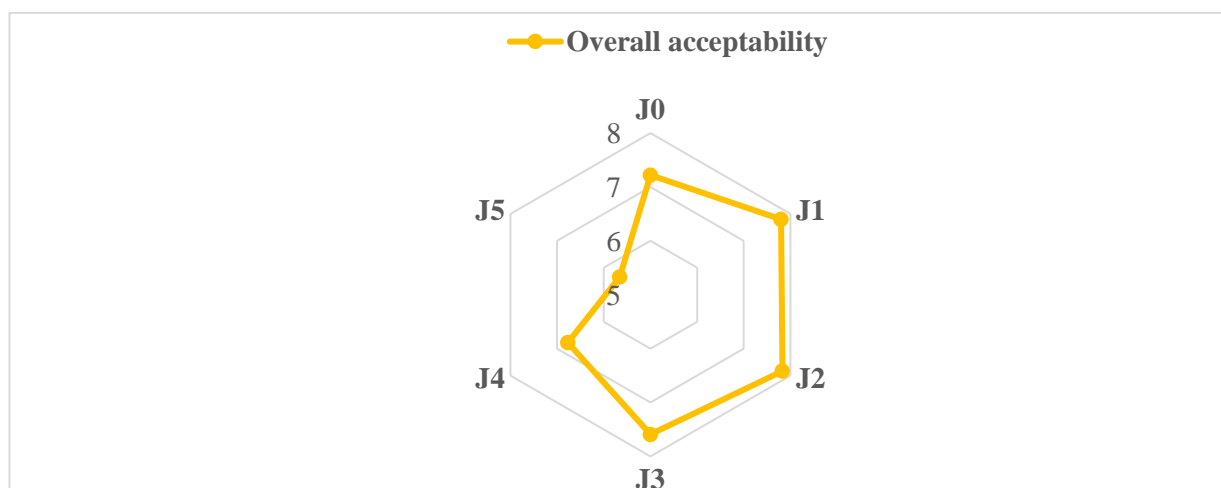


Fig 6: Effect of level of jaggery replacement to sugar on overall acceptability of *Shrikhandwadi*

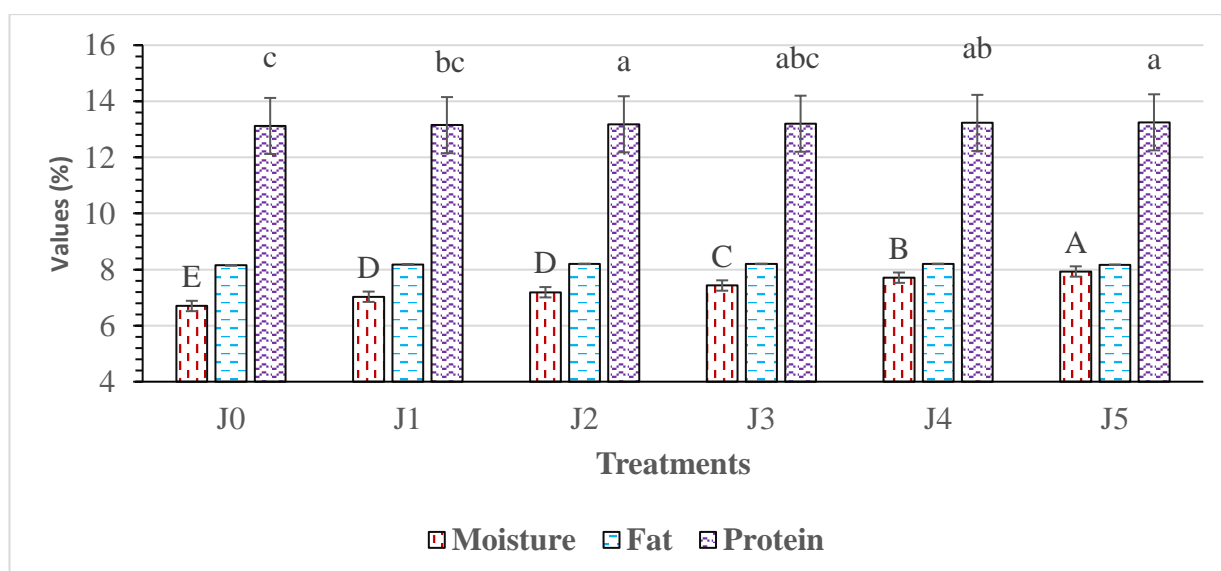


Fig 7: Effect of level of jaggery replacement to sugar on moisture, fat and protein content of *Shrikhandwadi* :bars with different alphabets differ significantly ($p < 0.05$).

Similar findings were presented by Sonwane and Sonkamble (2020) who in their study reported that the score for overall acceptability of shrikhand added with 41% jaggery was higher than shrikhand added with sugar and also shrikhand added with 51% jaggery.

Fig 7: Effect of level of jaggery replacement to sugar on moisture, fat and protein content of *Shrikhandwadi*

4.3.2 Effect of Level of Jaggery Replacement to Sugar on Chemical Composition of *Shrikhandwadi*

The *Shrikhandwadi* was prepared by using different levels of sugar/jaggery and it was analysed for moisture, fat, protein, lactose, non-reducing sugar and ash content and the results are presented in Table 11.

Table 11 Effect of level of jaggery replacement to sugar on chemical composition of *Shrikhandwadi*

Treatment	Moisture (%)	Fat (%)	Protein (%)	Reducing sugar (%)	Non reducing sugar (%)	Ash (%)
J ₀	6.70 ^e ± 0.07	8.15 ± 0.02	13.12 ^c ± 0.05	8.65 ^c ± 0.05	61.38 ^a ± 0.08	2.06 ^c ± 0.03
J ₁	7.03 ^d ± 0.06	8.17 ± 0.01	13.15 ^{bc} ± 0.04	10.71 ^c ± 0.01	59.22 ^b ± 0.08	2.14 ^c ± 0.02
J ₂	7.19 ^d ± 0.06	8.17 ± 0.01	13.18 ^a ± 0.02	12.58 ^b ± 0.04	57.18 ^c ± 0.06	2.15 ^{bc} ± 0.02
J ₃	7.43 ^c ± 0.04	8.18 ± 0.01	13.20 ^{abc} ± 0.03	14.30 ^b ± 0.04	55.23 ^d ± 0.08	2.18 ^{abc} ± 0.03
J ₄	7.71 ^b ± 0.03	8.20 ± 0.03	13.23 ^{ab} ± 0.01	16.08 ^a ± 0.04	53.45 ^e ± 0.08	2.20 ^{ab} ± 0.03
J ₅	7.93 ^a ± 0.04	8.20 ± 0.02	13.25 ^a ± 0.02	18.23 ^a ± 0.07	50.47 ^f ± 0.07	2.24 ^a ± 0.02
SEm	0.05	0.02	0.05	1.1	0.08	0.02
CD (<0.05)	0.17	NS	0.17	3.5	0.26	0.08

*Mean ± SE (n=4) within column followed by different superscript differ significantly (p<0.05) from each other

4.3.2.1 Moisture

From Table 11 and Fig. 7, it was observed that the moisture content of *Shrikhandwadi* ranged from 6.70 ± 0.07 to 7.93 ± 0.04%. Maximum moisture content was observed in treatment J₅(*Shrikhandwadi* added with 125% jaggery) whereas minimum in J₀(*Shrikhandwadi* added with 125% sugar). On replacement of jaggery to sugar from 25% to 125%, the moisture content of *Shrikhandwadi* increased significantly (p<0.05) which might be due to the hygroscopic nature of jaggery which is imparted by the presence of invert sugar, mineral salts and also higher moisture content present in jaggery (Mandal *et al.* 2006). The findings are in line with Gartaula *et al.* (2014) who reported that the jaggery added ‘Bomboyson’ had higher moisture content than sugar added ‘Bomboyson’. Similar findings were reported by Lamdande *et al.* (2018) who found that the

moisture content of muffins prepared with jaggery was higher than the muffins prepared using sugar.

Sonwane and Sonkamble (2020) also reported that the moisture content of control shrikhand (S_0) added with sugar was less as compared to shrikhand prepared using jaggery.

4.3.2.2 Fat

From Table 11 and Fig. 7, it can be observed that the fat content of the treatments J_0 , J_1 , J_2 , J_3 , J_4 and J_5 was 8.15 ± 0.02 , 8.17 ± 0.01 , 8.17 ± 0.01 , 8.18 ± 0.01 , 8.20 ± 0.03 , 8.20 ± 0.02 and % respectively. The effect of level of sugar/jaggery was non-significant on fat content of *Shrikhandwadi*. This might be due to absence of fat content in sugarcane jaggery too. The findings are in line with study of Gartaula *et al.* (2014) who reported that there was no significant difference in 'Bomboysen' prepared using sugar and that prepared using jaggery.

4.3.2.3 Protein

From Table 11 and Fig. 7, it can be observed that the protein content of *Shrikhandwadi* ranged from 13.12 ± 0.05 to $13.25 \pm 0.02\%$. The protein content of *Shrikhandwadi* for treatments J_0 , J_1 , J_2 , J_3 , J_4 and J_5 was 13.12 ± 0.05 , 13.15 ± 0.04 , 13.18 ± 0.02 , 13.20 ± 0.03 , 13.23 ± 0.01 and $13.25 \pm 0.02\%$ respectively. The results showed that the treatment J_5 had significantly higher protein content than all other treatments. This might be due to some amount of protein content in jaggery (Rao *et al.*, 2007 and Shrivastav *et al.*, 2016). Statistically it shows significant ($p < 0.05$) effect on protein content. The protein content increased as the level of jaggery replaced to sugar increased.

4.3.2.4 Reducing sugar

From Table 11 and Fig. 8, it can be observed that reducing sugar content of *Shrikhandwadi* of treatments J_0 , J_1 , J_2 , J_3 , J_4 and J_5 was 8.65 ± 0.05 , 10.71 ± 0.01 , 12.58 ± 0.04 , 14.30 ± 0.04 , 16.08 ± 0.04 and 18.23 ± 0.07 respectively. The results showed that the level of replacement of jaggery to sugar had significant effect on reducing sugar content of *Shrikhandwadi*. The reducing sugar content increased with increase in replacement of jaggery to sugar. The highest reducing sugar content was recorded for treatment J_5 and the lowest for treatment J_0 .

The increase in reducing sugar content might be due to the reducing sugar content present in jaggery. Hirpara *et. al* (2020) reported that solid, liquid and granular jaggery contains 9-15, 15-25 and 5-9% of reducing sugar respectively.

4.3.2.5 Non reducing sugar

From Table 11 and Fig. 9, it can be observed that non reducing sugar content of *Shrikhandwadi* ranged from 61.38 ± 0.08 to $50.47 \pm 0.07\%$. The highest value was recorded for treatment J_0 (*Shrikhandwadi* added with 125% sugar) and lowest to J_5 (*Shrikhandwadi* added with 125% jaggery). The results showed that as the level of replacement of sugar by jaggery increased the sucrose content of *Shrikhandwadi* decreased. This might be due more amount of non-reducing

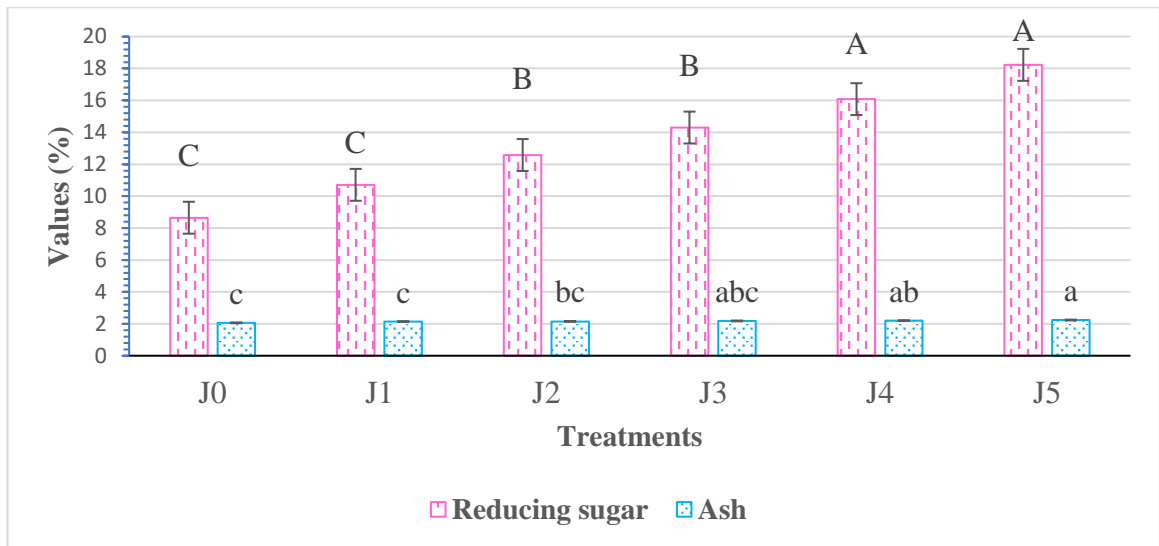


Fig 8: Effect of level of jaggery replacement to sugar on reducing sugar and ash content of Shrikhandwadi : bars with different alphabets differ significantly ($p < 0.05$).

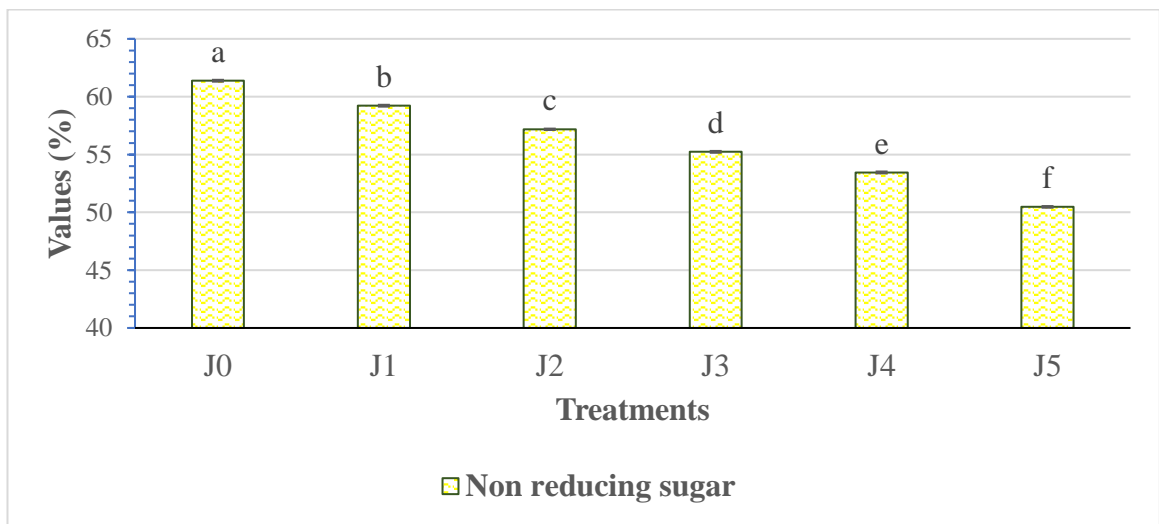


Fig 9: Effect of level of jaggery replacement to sugar on non-reducing sugar content of Shrikhandwadi : bars with different alphabets differ significantly ($p < 0.05$).

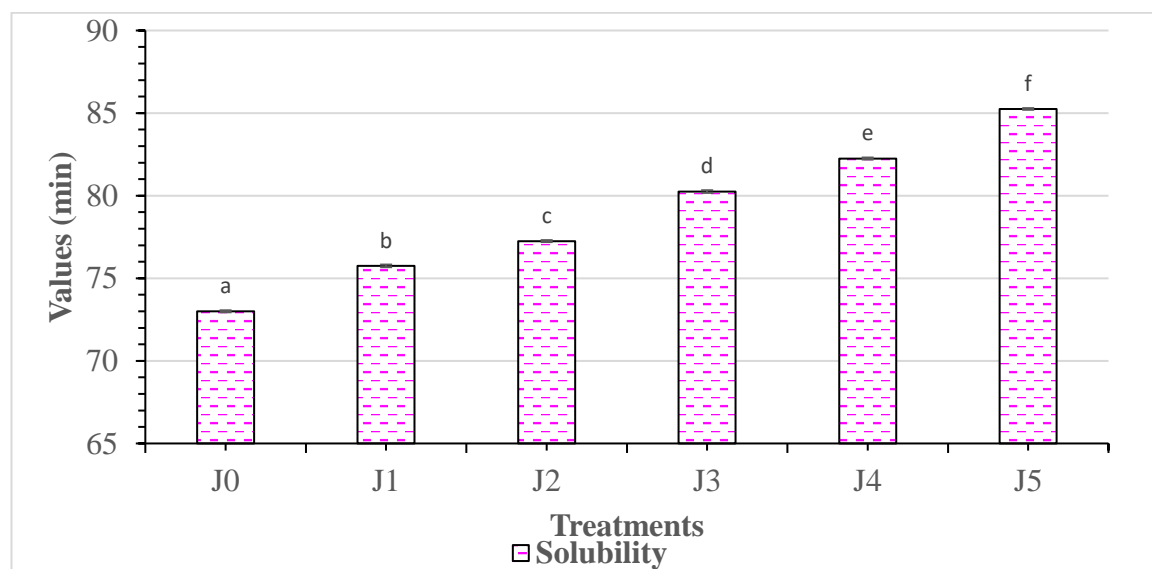


Fig 10: Effect of level of jaggery replacement to sugar on solubility (min) of Shrikhandwadi : bars with different alphabets differ significantly ($p < 0.05$).

sugar present in sugar than jaggery. Singh (1998) reported that jaggery contains 65-85% sucrose as compared to sugar which contains 99.5% sucrose. Similar findings by Lamdande *et al.* (2018) who reported that the sugar content of muffins with jaggery was found to be considerably lower than muffins prepared using sugar.

4.3.2.6 Ash

The data regarding ash content of *Shrikhandwadi* coded with J₀ to J₅ is presented in Table 11 and Fig. 8. The results revealed that the ash content of *Shrikhandwadi* ranged from 2.06 ± 0.03 to $2.24 \pm 0.02\%$. The ash content of *Shrikhandwadi* was significantly ($p < 0.05$) affected by the increase in level of replacement of jaggery. The ash content of *Shrikhandwadi* increased as the level of replacement of sugar by jaggery was increased. The increase in ash content might be due to the presence of higher amount of minerals like iron, calcium, phosphorous in jaggery as reported Rao *et al.* (2007). Gartaula *et al.* (2007) also reported that the mineral content of jaggery ranges from 0.6-1% while sugar contains only 0.05% (Singh 1998). Lamdande *et al.* (2018) reported that the ash content of muffins with jaggery was higher than the muffins with sugar. Sonwane and Sonkamble (2020) also reported that the ash content increased by 0.35% in value added shrikhand in comparison to control due to the addition of jaggery.

Present findings are in accordance with the findings of by Gavali *et al.* (2020) in the preparation of jaggery basundi who reported that the ash content of basundi increased with increase in level of addition of jaggery from 6% to 8%.

4.3.3 Effect of Level of Jaggery Replacement to Sugar on Solubility and Acidity of *Shrikhandwadi*.

Table 12 Effect of level of jaggery replacement of sugar on solubility and acidity of *Shrikhandwadi*.

Treatment	Solubility (min.)	Acidity (%LA)
J ₀	$73.00^f \pm 0.06$	$1.31^d \pm 0.02$
J ₁	$75.75^e \pm 0.08$	$1.33^{cd} \pm 0.02$
J ₂	$77.25^d \pm 0.06$	$1.36^{bc} \pm 0.02$
J ₃	$80.25^c \pm 0.08$	$1.39^{ab} \pm 0.01$
J ₄	$82.25^b \pm 0.06$	$1.42^a \pm 0.01$
J ₅	$85.25^a \pm 0.05$	$1.44^a \pm 0.01$
SEm	0.5	0.01
CD (<0.05)	1.63	0.05

*Mean \pm SE (n=4) within column followed by different superscript differ significantly ($p < 0.05$) from each other

4.3.3.1 Effect on solubility

From Table 12 and Fig.10, it could be observed that the solubility of *Shrikhandwadi* ranged from 73.00 ± 0.06 to 85.25 ± 0.05 min. The minimum time required for solubilization of *Shrikhandwadi* was recorded for product prepared by addition of sugar @ 125% of chakka. The

maximum time required for solubilization of *Shirkhandwadi* was recorded for the formulation containing 125% jaggery of chakka. The result reveals that the time required for solubilization of *Shrikhandwadi* was significantly ($p<0.05$) affected by the level of addition of sugar/jaggery. As the level of replacement of jaggery to sugar increased the solubility of *Shrikhandwadi* decreased.

4.3.3.2 Effect on acidity

From Table 12 and Fig. 11, it can be observed that the acidity of *Shrikhandwadi* for treatments J₀, J₁, J₂, J₃, J₄ and J₅ was 1.31 ± 0.02 , 1.33 ± 0.02 , 1.36 ± 0.02 , 1.39 ± 0.01 , 1.42 ± 0.01 and $1.44 \pm 0.01\%$ LA respectively. The highest acidity ($1.44 \pm 0.01\%$ LA) was recorded for treatment J₅ and lowest for J₀($1.31 \pm 0.02\%$). The influence of experimental treatments on acidity content of *Shrikhandwadi* was significant ($p<0.05$). All the treatment samples differed significantly from each other. The results revealed that the acidity of *Shrikhandwadi* increased with increase in the level of replacement of sugar by jaggery. It might be due to the slight acidic nature of jaggery, which has pH value of 5.07-6.20 as reported by Nayaka *et al.* (2015).

Similar finding was reported by Gavali *et al.* (2020) who mentioned that the acidity of basundi increased with increase in level of jaggery in basundi.

4.3.4 Effect of Level of Replacement of Jaggery to Sugar on Hunter Colour Value of *Shrikhandwadi*

Table 13 and Fig. 12 depicts the lightness, redness and yellowness values of *Shrikhandwadi*. The level of replacement of sugar by jaggery had significant ($p<0.05$) effect on lightness, redness and yellowness values of *Shrikhandwadi*. The lightness values decreased from 58.63 ± 0.08 to 21.83 ± 0.04 indicating that the addition of jaggery increases the darkness of *Shrikhandwadi* progressed. The highest value was recorded for treatment J₀ and lowest for treatment J₅. This could be due to replacement of sugar by jaggery at different levels in *Shrikhandwadi* which imparted brown colour to *Shrikhandwadi*.

Table 13 Effect of level of replacement of jaggery to sugar on Hunter colour value of *Shrikhandwadi*

Treatment	L*	a*	b*
J ₀	$58.63^a \pm 0.08$	$0.48^d \pm 0.02$	$15.23^a \pm 0.03$
J ₁	$38.55^b \pm 0.09$	$6.13^c \pm 0.05$	$13.79^b \pm 0.06$
J ₂	$29.55^c \pm 0.04$	$7.50^b \pm 0.05$	$11.98^c \pm 0.09$
J ₃	$26.57^d \pm 0.05$	$7.72^b \pm 0.05$	$10.69^d \pm 0.07$
J ₄	$26.03^c \pm 0.02$	$7.81^b \pm 0.02$	$10.62^d \pm 0.03$
J ₅	$21.83^f \pm 0.04$	$8.22^a \pm 0.02$	$8.38^e \pm 0.06$
SEm	0.06	0.04	0.06
CD (<0.05)	0.19	0.12	0.19

*Mean \pm SE (n=4) within column followed by different superscript differ significantly ($p<0.05$) from each other

The redness-greenness (a^*) values ranged from 0.48 ± 0.02 to 8.22 ± 0.02 . The values differed significantly ($p < 0.05$) from J_0 to J_5 . The highest a^* value was observed for treatment J_5 and the lowest for treatment J_0 . The increase in values of a^* indicated that the replacement of

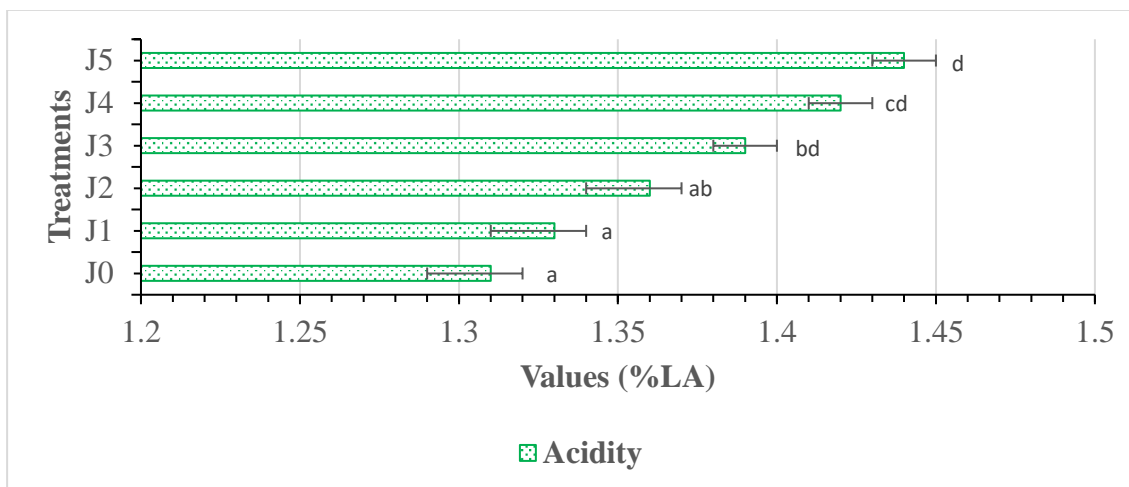


Fig 11: Effect of level of jaggery replacement to sugar on acidity of *Shrikhandwadi* : bars with different alphabets differ significantly ($p < 0.05$).

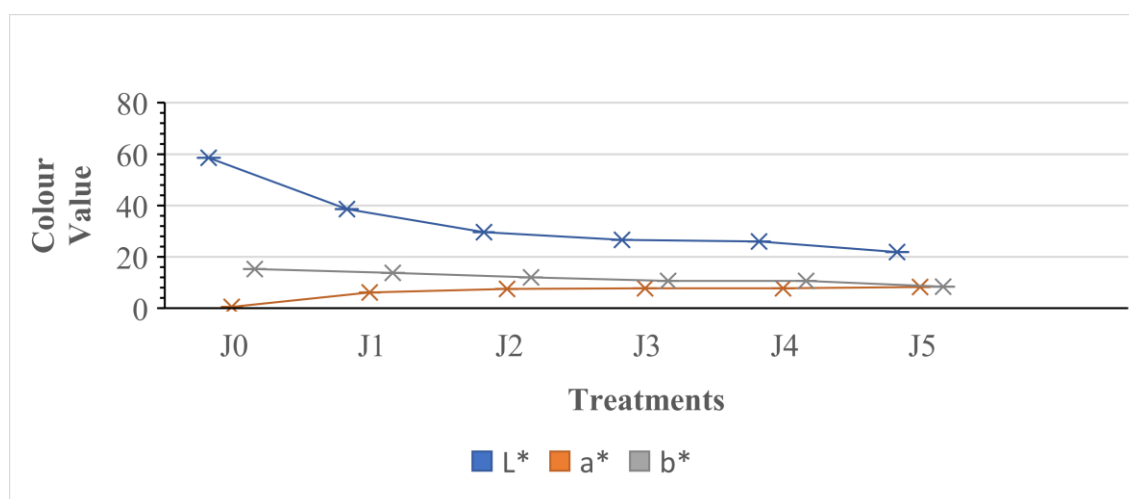


Fig 12: Effect of level of jaggery replacement to sugar on Hunter colour value of *Shrikhandwadi* : bars with different alphabets differ significantly ($p < 0.05$).

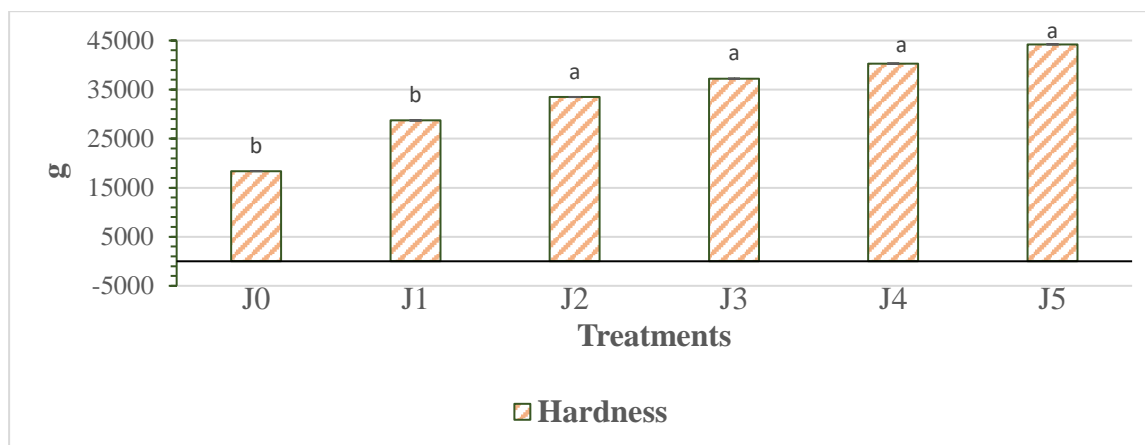


Fig 13: Effect of level of replacement of jaggery to sugar on hardness of *Shrikhandwadi*.: bars with different alphabets differ significantly ($p < 0.05$).

jaggery to sugar increased the redness of *Shrikhandwadi*. It might be due to golden yellow to golden brown colour of jaggery as reported by Deotale *et al.* (2019).

The yellowness-blueness values of *Shrikhandwadi* decreased from 15.23 ± 0.03 to 8.38 ± 0.06 . The b^* value of the different treatments of *Shrikhandwadi* was significantly ($p < 0.05$) affected by the level of replacement of sugar by jaggery. The highest value was recorded for treatment J_0 (15.23 ± 0.03) and lowest for treatment J_5 (8.38 ± 0.06).

The decrease in lightness, increase in redness and decrease in yellowness values was due to increase in level of replacement of jaggery to sugar. Similar findings were reported by Lamdande *et al.* (2018) in the muffins made from wheat flour and jaggery. The findings were in accordance with Tanuja *et al.* (2017) in apple pomace incorporated burfi and Pandey and Poonia (2020) in ber burfi.

4.3.5. Effect of Level of Jaggery Replacement to Sugar on Texture Profile of *Shrikhandwadi*

4.3.5.1 Hardness

For the analysis of texture, hardness is the most commonly evaluated characteristic. The hardness value is the peak force of first compression of the product during the textural determination. As a sensory property, hardness is determined as the force required to compress a substance between molar teeth or between tongue and palate. The hardness value is expressed in terms of grams.

The hardness of *Shrikhandwadi* ranged from 18385.75 ± 39.6 to 44228.71 ± 87.6 . The values of hardness for treatments J_0 , J_1 , J_2 , J_3 , J_4 and J_5 were 18385.75 ± 39.6 , 28718 ± 40.4 , 33483.33 ± 41.9 , 37222.72 ± 65.3 , 40300.15 ± 53.6 and 44228.71 ± 87.6 g respectively. The hardness of a product depends on many factors. The results in the Table 14 and Fig. 13 revealed that the hardness of *Shrikhandwadi* increased with increase in level of replacement of sugar by jaggery. Interestingly it was found that sensorially the product was soft upon increase in the level of jaggery, however instrumental hardness value was increased, and this might be due to more chewiness in product upon increase in the level of jaggery.

The results are in line with Gupta *et al.* (2007) who reported that hardness of sunflower-sesame kernel confection prepared by using jaggery was increased.

4.3.5.2 Adhesiveness

Adhesiveness is sometimes referred as stickiness. It is the force required to remove the material that adheres to the mouth during normal eating process. The negative forces area of the first bite is defined as adhesiveness. It is expressed in terms of gram second (g.s). The values obtained for adhesiveness of *Shrikhandwadi* ranged from -23.47 ± 0.04 to -1.92 ± 0.06 g.sec. The highest value was obtained for treatment J_5 (*Shrikhandwadi* added with 125% jaggery) and the lowest value was obtained for treatment J_0 (*Shrikhandwadi* added with 125% sugar). The values

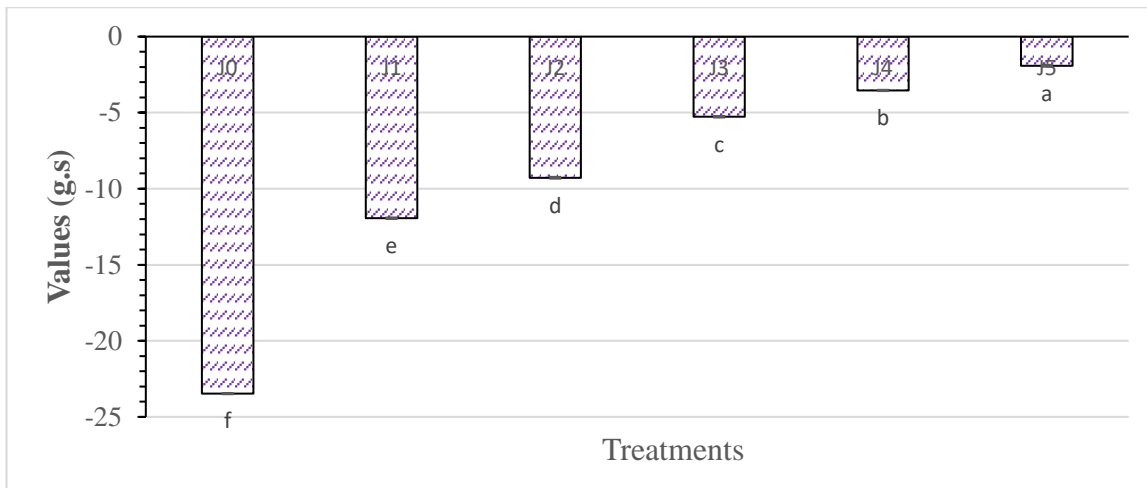


Fig 14: Effect of level of jaggery replacement to sugar on adhesiveness of Shrikhandwadi.: bars with different alphabets differ significantly ($p < 0.05$).

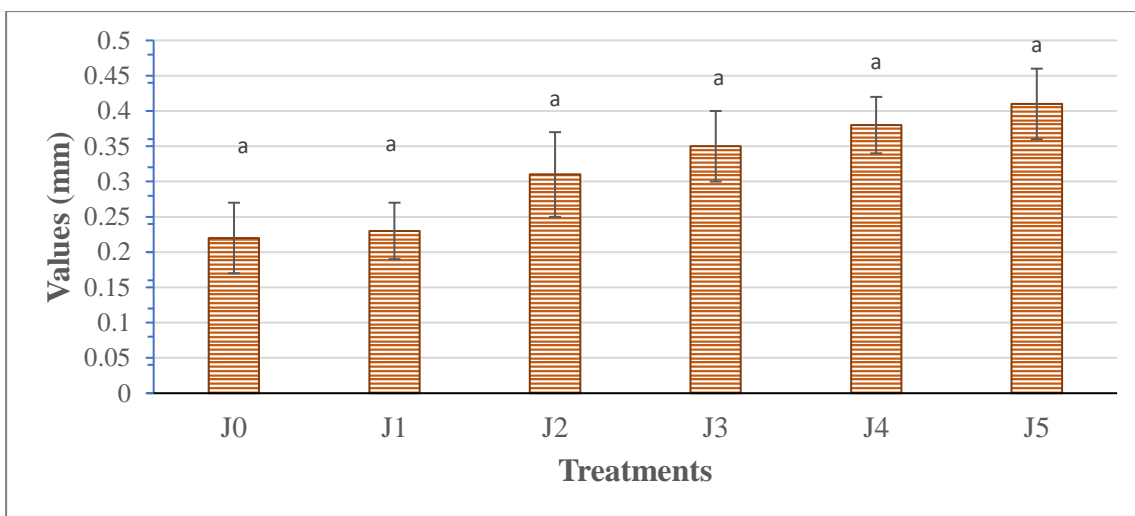


Fig 15: Effect of level of jaggery replacement to sugar on springiness values of Shrikhandwadi : bars with different alphabets differ significantly ($p < 0.05$).

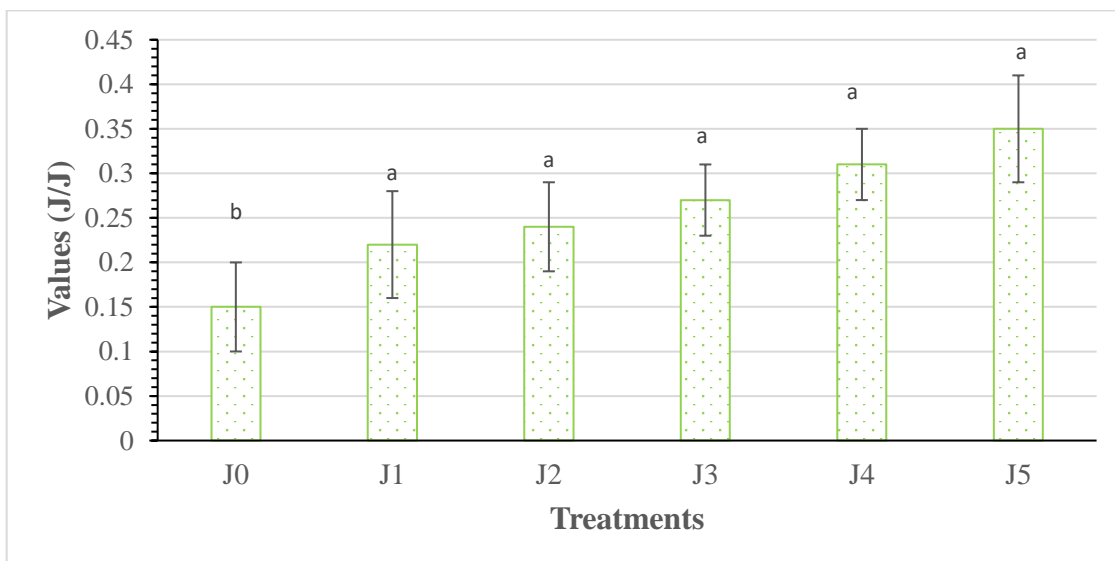


Fig 16: Effect of level of jaggery replacement to sugar on cohesiveness values of Shrikhandwadi: bars with different alphabets differ significantly ($p < 0.05$).

for adhesiveness differed significantly ($p < 0.05$) from each other. The values for adhesiveness increased with increase in level of replacement of sugar by jaggery.

Table 14 Effect of level of jaggery replacement to sugar on texture profile of *Shrikhandwadi*

Treatment	Hardness (g)	Adhesiveness (g.sec)	Springiness (mm)	Cohesiveness (J/J)	Chewiness (N-mm)	Guminess (N)
J ₀	18385.75 ^b ±39.6	-23.47 ^f ±0.04	0.22 ^a ±0.05	0.15 ^b ±0.05	955.32 ^f ±4.7	2914.22 ^f ±15.0
J ₁	28718 ^b ±40.4	-11.94 ^e ±0.05	0.23 ^a ±0.04	0.22 ^a ±0.06	1699.63 ^e ±3.2	5295 ^e ±8.1
J ₂	33483.33 ^a ±41.9	-9.28 ^d ±0.06	0.31 ^a ±0.06	0.24 ^a ±0.05	2153.70 ^d ±2.8	7549.79 ^d ±9.1
J ₃	37222.72 ^a ±65.3	-5.27 ^c ±0.05	0.35 ^a ±0.05	0.27 ^a ±0.04	3205.64 ^c ±2.04	9613.67 ^c ±8.1
J ₄	40300.15 ^a ±53.6	-3.54 ^b ±0.04	0.38 ^a ±0.04	0.31 ^a ±0.04	4594.33 ^b ±1.2	13040.48 ^b ±9.4
J ₅	44228.71 ^a ±87.6	-1.92 ^a ±0.06	0.41 ^a ±0.05	0.35 ^a ±0.06	5009.54 ^a ±3.6	15648.24 ^a ±4.0
SEm	3799.43	0.05	0.04	0.05	5.04	6.5
CD	11288.69	0.28	0.26	0.17	14.99	19.42

*Mean ± SE (n=4) within column followed by different superscript are differ significantly ($p < 0.05$) from each other

4.3.5.3 Springiness

Springiness is the degree to which a product returns to its original shape after compression with the teeth. The values for springiness of *Shrikhandwadi* ranged from 0.22 to 0.41. The values obtained for springiness for treatment J₀, J₁, J₂, J₃, J₄ and J₅ were 0.22±0.05, 0.23±0.04, 0.31±0.06, 0.35±0.05, 0.38±0.04 and 0.41±0.05 mm respectively. The results revealed that the springiness of product increased with the level of replacement of sugar by jaggery. The values for springiness significantly ($p < 0.05$) differed from each other.

Contradictory results were found by Figiel *et al.* (2006) who reported that the springiness of candies decreased with increase in moisture whereas the springiness in present findings increased with the increase in moisture due to increase in level of replacement of sugar by jaggery.

4.3.5.4 Cohesiveness

Cohesiveness is the ratio of areas under the first and second bite. It is defined as the extent to which a material can be deformed before its rupture and it mainly depends upon the strength of internal bonds. In other words, it refers to how a product stays together after deformation and it is unit less. The values for cohesiveness ranged from 0.15±0.05 to 0.35±0.06 J/J. The highest value was obtained for treatment J₅ (*Shrikhandwadi* added with 125% jaggery) and lowest score was

obtained for treatment J₀ (*Shrikhandwadi* added with 125% sugar). The results revealed that the values for cohesiveness significantly ($p < 0.05$) differed from each other.

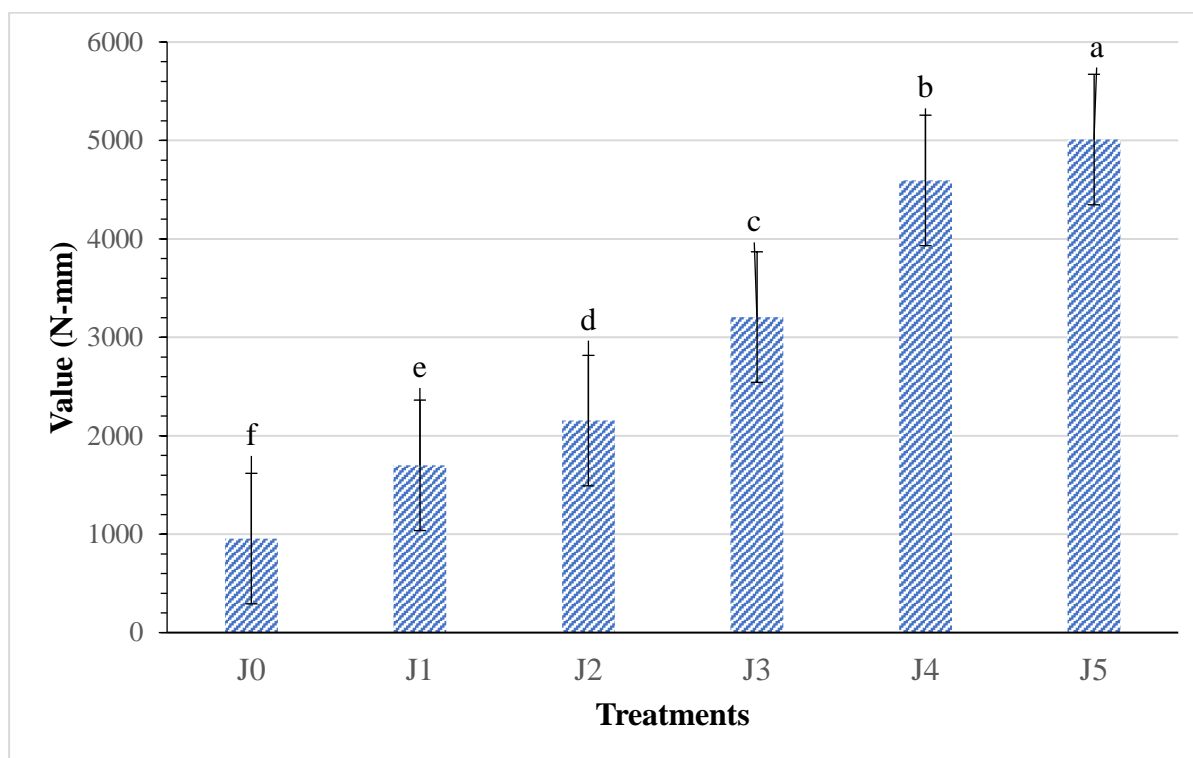


Fig 17: Effect of level of jaggery replacement to sugar on chewiness values of *Shrikhandwadi* : bars with different alphabets differ significantly ($p < 0.05$).

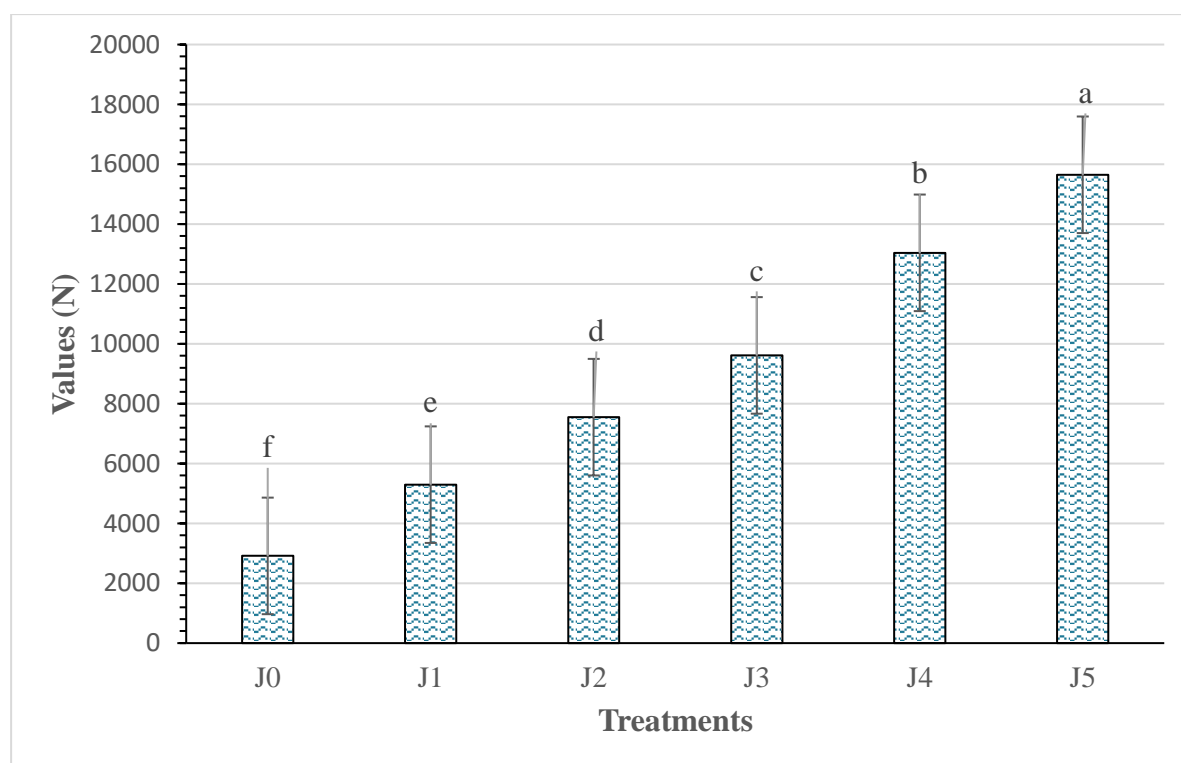


Fig 18: Effect of level of jaggery replacement to sugar on guminess values of *Shrikhandwadi* : bars with different alphabets differ significantly ($p < 0.05$).

The findings are in line with the study of Wasnik *et al.* (2013) who studied the textural properties of santra burfi and reported that the cohesiveness increased with increase in moisture content of the product. Similar findings were recorded by Singh *et al.* (2020) while studying textural analysis of camel and buffalo milk based khoa burfi blended with watermelon seeds.

4.3.5.5 Chewiness

Chewiness is the length of time required to masticate the sample at constant rate of force application to reduce it to consistency suitable for swallowing. The values obtained for chewiness of *Shrikhandwadi* for treatment J₀, J₁, J₂, J₃, J₄ and J₅ were 955.32±4.7, 1699.63±3.2, 2153.70±2.8, 3205.64±2.04, 4594.33±1.2 and 5009.54±3.6 N-mm respectively. The results revealed that the chewiness of product increased with the level of replacement of sugar by jaggery. The highest value for chewiness was obtained by treatment J₅(*Shrikhandwadi* added with 125% jaggery) and lowest by J₀(*Shrikhandwadi* added with 125% sugar). Contradictory results were found by Figiel *et al.* (2006) who reported that the springiness of candies decreased with increase in moisture whereas the springiness in present findings increased with the increase in moisture due to increase in level of replacement of sugar by jaggery.

4.3.5.6 Guminess

Guminess is defined as the energy required to disintegrate a food to a state ready for swallowing. The values obtained for chewiness of *Shrikhandwadi* ranged from 2914.22±15.06 to 15648.24±4.0. The values obtained for chewiness of *Shrikhandwadi* for treatment J₀, J₁, J₂, J₃, J₄ and J₅ were 2914.22±15.06, 5295.97±8.1, 7549.79±9.1, 9613.67±8.1, 13040±9.4 and 15648.24±4.0 respectively. The findings were in line with Gupta *et al.* (2007) in the preparation of sunflower- sesame confection using jaggery.

The findings are in line with Wasnik *et al.* (2013) who studied the textural properties of santra burfi and reported that the cohesiveness increased with increase in moisture content of the product. Similar findings were noticed by Singh *et al.* (2020) who studied textural analysis of camel and buffalo milk based khoa burfi blended with watermelon seeds.

4.4. Effect of Temperature-time Combination on Sensory Attributes of *Shrikhandwadi*

Various conventional methods of drying such as air drying, sun drying etc. are used to increase the shelf life of foods. Air drying has been reported to be used frequently in food industry for drying various fruits and vegetables (Konopacka, 2006) as it is a feasible method of preserving them. However, drying is an energy intensive process and proper knowledge is required to maximize the drying efficiency to maintain the product quality. In any drying process, the main aim will always be to obtain product of desired quality at a minimum cost (Rakshit *et al.*, 2015). Taking into consideration the importance of air drying, in the present investigation *Shrikhandwadi* was dried in cabinet air dryer at various temperature-time combinations.

The *Shrikhandwadi* prepared was kept in cabinet air dryer for partial evaporation of moisture at 40-60°C. The quality of *Shrikhandwadi* was evaluated at 15 and 30 min. regular interval. The treatments were coded as T₁ (40°C for 15 min), T₂ (40°C for 30 min), T₃ (50°C for 15 min), T₄ (50°C for 30 min), T₅ (60°C for 15 min) and T₆ (60°C for 30 min). The temperature and minimum time required to obtain superior quality of *Shrikhandwadi* was optimized based on sensory evaluation.

Table 15 Effect of temp-time combination on sensory attributes of *Shrikhandwadi*

Treatment	Sensory attributes (Score*)			
	Colour and appearance	Flavour	Body and texture	Overall acceptability
T ₀	8.31 ^a ± 0.06	8.29 ^a ± 0.07	6.90 ^d ± 0.06	7.83 ^b ± 0.02
T ₁	8.26 ^a ± 0.02	8.21 ^a ± 0.04	8.24 ^a ± 0.02	8.23 ^a ± 0.02
T ₂	8.18 ^{ab} ± 0.03	8.20 ^a ± 0.03	8.18 ^a ± 0.03	8.18 ^a ± 0.02
T ₃	8.05 ^b ± 0.06	8.04 ^a ± 0.05	7.89 ^b ± 0.04	7.97 ^b ± 0.06
T ₄	7.79 ^c ± 0.04	7.84 ^b ± 0.02	7.24 ^c ± 0.02	7.62 ^c ± 0.03
T ₅	7.25 ^d ± 0.02	7.70 ^c ± 0.02	7.05 ^d ± 0.06	7.33 ^d ± 0.02
T ₆	7.05 ^e ± 0.06	7.50 ^d ± 0.06	6.55 ^e ± 0.06	7.03 ^e ± 0.06
SEm	0.05	0.05	0.07	0.04
CD (p<0.05)	0.15	0.17	0.21	0.13

*Mean ± SE (n=4) within column followed by different superscript differ significantly (p<0.05) from each other

4.4.1 Effect on Colour and Appearance of *Shrikhandwadi*

The result depicted in Table 15 and Fig. 19 revealed that the effect of temperature-time combination required for drying of *Shrikhandwadi* significantly affected the colour and appearance score of *Shrikhandwadi*. The score for colour and appearance was highest for treatment T₁(*Shrikhandwadi* dried at 40°C for 15 min) and lowest score was obtained by treatment T₆(*Shrikhandwadi* dried at 60°C for 30 min). The results revealed that as the drying temperature increased the colour became dull and the product became cracky in appearance.

4.4.2 Effect on Flavour of *Shrikhandwadi*

From Table 15 and Fig. 19, it can be observed that the score for flavour for treatments T₁ to T₆ was 8.21 ± 0.04, 8.20 ± 0.03, 8.04 ± 0.05, 7.84 ± 0.02, 7.70 ± 0.02 and 7.50 ± 0.06 respectively. The highest score was obtained by *Shrikhandwadi* dried at 40°C for 15 minutes and lowest by *Shrikhandwadi* dried at 60°C for 30 minutes. The results revealed that the as the drying temperature increased the score obtained for flavour by *Shrikhandwadi* decreased. Similar findings by Toradmal (2017) in *Shrikhandwadi* enriched with whey protein concentrate.

4.4.3 Effect on Body and Texture of *Shrikhandwadi*

Table 15 and Fig. 20 reveals that the score for body and texture ranged from 8.24 ± 0.02 to 6.55 ± 0.06. The scores for treatments T₁, T₂, T₃, T₄, T₅ and T₆ was 8.24±0.02, 8.18±0.03, 7.89±0.04, 7.24±0.02, 7.05±0.06 and 6.55±0.06 respectively. The maximum score for body and texture was recorded for *Shrikhandwadi* dried at 40°C for 15 minutes as the *Shrikhandwadi* had

expected hardness and was easy to break. The results revealed that as the drying temperature increased the score for body and texture decreased.

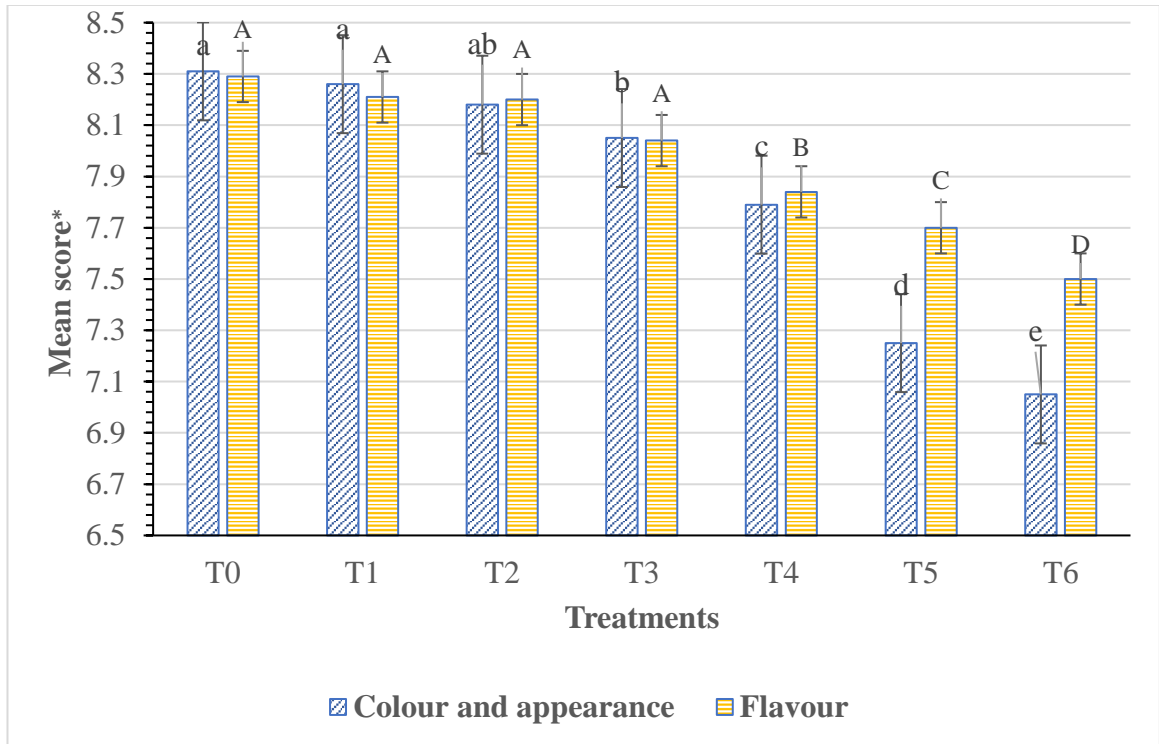


Fig 19: Effect of temp-time combination on colour and appearance and flavour of *Shrikhandwadi* : bars with different alphabets differ significantly ($p < 0.05$).

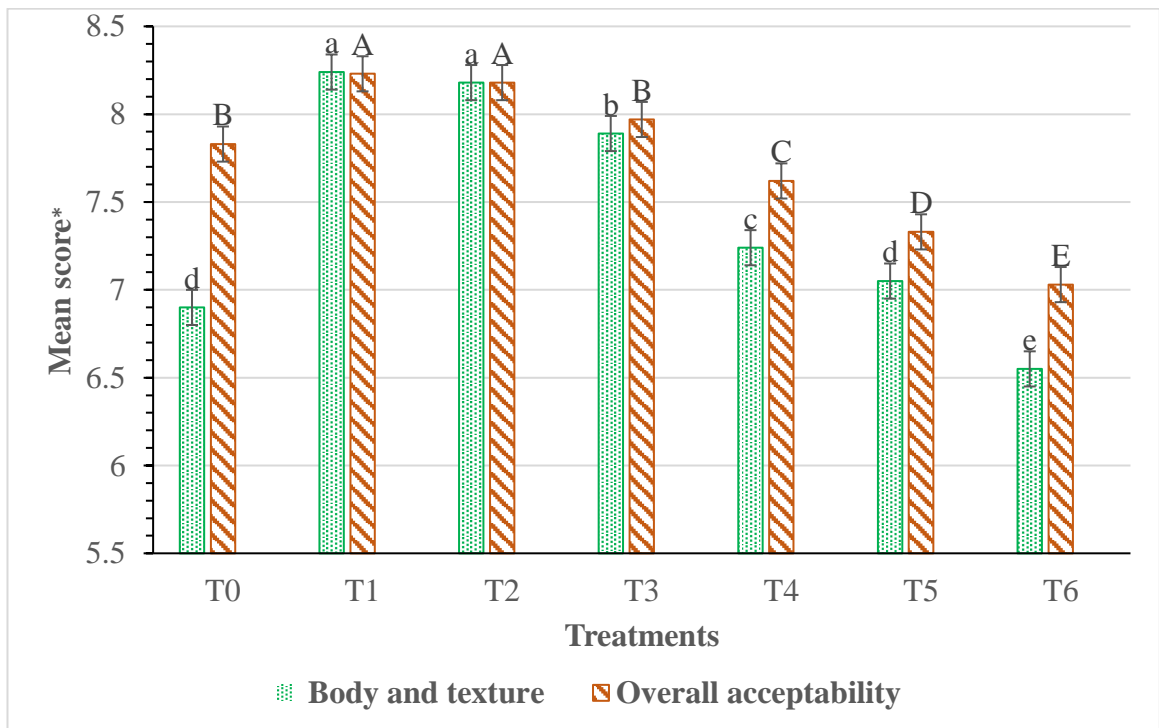


Fig 20: Effect of temp-time combination on body and texture and overall acceptability of *Shrikhandwadi* : bars with different alphabets differ significantly ($p < 0.05$).

4.4.4 Effect on Overall Acceptability of *Shrikhandwadi*

The score for overall acceptability of *Shrikhandwadi* was significantly ($P < 0.05$) affected by temperature-time combination during drying as influenced by the score for colour and appearance, flavour and body and texture. The score for overall acceptability ranged from 8.23 ± 0.02 to 7.03 ± 0.06 . The highest score was obtained by *Shrikhandwadi* dried at 40°C for 15 minutes. The study revealed that the optimum product could be obtained by drying the *Shrikhandwadi* at 40°C for 15 minutes as the *Shrikhandwadi* dried at 40°C for 15 minutes had maximum score for sensory attributes.

4.5 Optimized Flow Diagram for Preparation of *Shrikhandwadi*

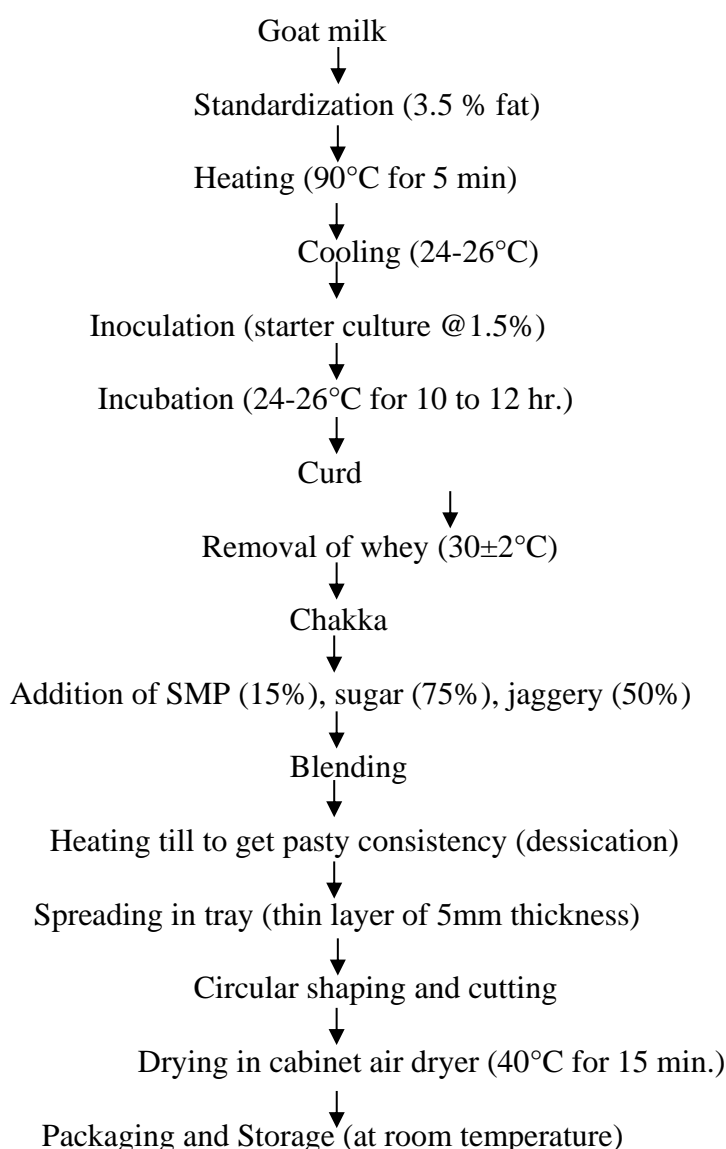


Fig. 21 Optimized Flow Diagram for Preparation of *Shrikhandwadi*

Initially goat milk was standardized at 3.5 percent fat, which was then heated and cooled to room temperature. The milk was then inoculated with starter culture @ 1.5g per kg of milk and then incubated at $24-26^\circ\text{C}$ for 10 to 12 h. The obtained dahi was then transferred to muslin cloth and hung for 10-12 h to remove free whey. The semi-solid mass thus obtained called as “chakka”.

The chakka was mixed with sugar 75%, jaggery 50%, 15% SMP followed by blending cum mixing in mixer to have smooth and homogenous consistency. The homogeneous mass was then transferred in non-sticky pan and heated to get pasty consistency followed by spreading in a tray in a thin layer. The product was cut into desired shape (circular of 4mm thickness) and allowed to dry in cabinet air dryer at 40°C for 15 min.

4.6. Sensory Score and Physico-Chemical Composition of Optimized *Shrikhandwadi*

Table 16 Sensory score and physico-chemical composition of optimized *Shrikhandwadi*

Sr no.	Sensory attributes	Score	Sr no.	Physico-chemical composition	Values
1.	Colour and appearance	8.31 ± 0.06	6.	Moisture (%)	7.19 ± 0.06
2.	Flavour	8.29 ± 0.07	7.	Fat (%)	8.17 ± 0.02
3.	Body and texture	6.90 ± 0.06	8.	Protein (%)	13.18 ± 0.02
4.	Overall acceptability	7.83 ± 0.02	9.	Reducing sugar (%)	12.58 ± 0.04
			10.	Non reducing sugar (%)	57.18 ± 0.06
			11.	Ash (%)	2.15 ± 0.02
			12.	Acidity (% LA)	1.36 ± 0.02
			13.	Solubility (min.)	77.25 ± 0.06

From Table 16, it can be observed that the optimized *Shrikhandwadi* had score 8.31 ± 0.06, 8.29 ± 0.07, 7.90 ± 0.06 and 8.17 ± 0.02 for colour and appearance, flavour, body and texture and overall acceptability respectively. The product contained 7.19 ± 0.06, 8.20 ± 0.02, 15.18 ± 0.02, 11.65 ± 0.02, 63.40 ± 0.08, 2.15 ± 0.02% moisture, fat, protein, reducing sugar, non-reducing sugar and ash respectively. The acidity(%LA) and solubility of the product were found to be 1.36 ± 0.02% and 77.25 ± 0.06 min respectively.

4.7 Comparison of Experimental Sample with Market Sample

The product thus optimized was compared with the market sample for sensory attributes, physico-chemical composition, Hunter colour value and texture profile. The results thus obtained are presented below.

4.7.1 Comparative Sensory Analysis of Experimental Sample and Market Sample

Sensory analysis was carried out for the experimental *Shrikhandwadi* sample and best quality market sample in terms of colour and appearance, flavour, body and texture and overall acceptability.

In order to make comparison between market sample and experimental sample 't' test was applied. The 't' values thus obtained are depicted in Table 17 which were 16.06, 11.10, 0.12 and 19.84 for colour and appearance, flavour, body and texture and overall acceptability respectively. The results revealed that the difference between market sample and experimental sample for colour and appearance, flavour and overall acceptability was found to be significant whereas that for body and texture was found to be non-significant.

Table 17 Comparative sensory score of experimental sample and market sample

Sample	Sensory attributes			
	Colour and appearance	Flavour	Body and texture	Overall acceptability
Market sample	7.30 ± 0.04	7.45 ± 0.03	6.90 ± 0.06	7.55 ± 0.06
Experimental sample	8.31 ± 0.06	8.29 ± 0.07	6.90 ± 0.05	7.83±0.02
't' value	16.06*	11.10*	NS	19.84*

*Mean±SD (n=3) significantly different at p<0.05

The score for colour and appearance for market sample and experimental sample was 7.86 ± 0.04 and 8.31 ± 0.06 respectively. It was revealed that the score obtained by the experimental sample was more than of the market sample which might be due to natural brownish colour of prepared *Shrikhandwadi*. The appealing brownish colour with faint red tinges of *Shrikhandwadi* may be due to the colour of jaggery as reported by Khulve *et al.* (2016) and they found that the colour of jaggery varies from golden yellow brown to dark brown in colour. The score for flavour was 7.80 ± 0.03 and 8.29 ± 0.07 for market sample and prepared sample respectively. The score obtained by experimental sample was more than the score obtained by market sample which might be due to the flavour of jaggery and sugar in experimental sample whereas market sample was sweeter in taste as it was added with only sugar. Another reason for lower score of market sample may be due to the use of artificial flavour in the preparation of *Shrikhandwadi* which may not match the flavour of shrikhand. Jaggery also has unique sweet taste (Deotale *et al.* 2019) which might be responsible for higher score of experimental *Shrikhandwadi* sample than market sample.

Table 17 shows that the score for body and texture for market and experimental sample was 6.90 ± 0.06 and 6.90 ± 0.06 respectively which showed that there was non-significant effect between body and texture score of market sample and experimental sample. The score for overall acceptability is depicted in Table 17. The overall acceptability of experimental sample was 7.83 ± 0.02 as against 7.55 ± 0.06 for market sample. The partial replacement of sugar by jaggery increased the overall acceptability of experimental sample as compared to market sample.

4.7.2 Comparative Physico-chemical Analysis of Experimental Sample and Market Sample

Proximate analysis of *Shrikhandwadi* sweetened by sugar/jaggery was done and compared with market sample.

The 't' table values for moisture, fat, protein, non-reducing sugar, ash, acidity and solubility were 46.36, 108.94, 56.57, 7.93, 4.86, 45.38 and 16.56 respectively. The results showed that the market sample and experimental sample were significantly different in terms of moisture, fat, protein, non-reducing sugar, ash, acidity content and solubility.

From Table 18, it was observed that the moisture content of market sample was 4.5 ± 0.04 and that of prepared sample was 7.19 ± 0.06 . the 't' value. The moisture content of market sample

was lower than that of experimental sample which might be due to change in ingredients and processing conditions.

Table 18 Comparative physico-chemical properties of experimental sample and market sample

Sample	Moisture (%)	Fat (%)	Protein (%)	Non-reducing sugar (%)	Ash (%)	Acidity (%)	Solubility (min)
Market sample	5.20±0.04	0.42±0.02	2.25±0.04	90.98±0.04	1.15±0.03	0.73±0.05	65.00±0.04
Experimental sample	7.19±0.06	8.17±0.01	13.18±0.02	57.18±0.06	2.15±0.02	1.36±0.02	77.25±0.06
't' value	46.36*	108.94*	56.57*	7.93*	4.86*	45.38*	16.56*

*Mean±SD (n=3) significantly different at p<0.05

The fat content of market sample was 0.42 ± 0.03 and that of prepared sample was found to be 8.17 ± 0.01 which revealed that the experimental *Shrikhandwadi* contained relatively higher amount of fat than the market sample. Similarly, the protein content of the market sample and experimental sample was higher ($13.18 \pm 0.02\%$) than the market sample which proves the nutritional importance of experimental sample. The probable reason for the difference in the fat and protein content of market sample and experimental sample may be the difference in the use of base material used for the preparation of *Shrikhandwadi*. The non-reducing sugar content of market sample and experimental sample was 82.84 ± 0.05 and $57.18 \pm 0.06\%$ respectively. The result reveals that the non-reducing sugar content of market sample was higher than that of prepared sample. It might be due to partial replacement of sugar by jaggery in the prepared sample. The ash content of market sample and prepared sample was 1.46 ± 0.04 and $1.15 \pm 0.02\%$ respectively. The ash content of market sample was found to be greater than the prepared *Shrikhandwadi* sample.

The acidity of market sample was $0.73 \pm 0.05\%$ LA and that of prepared sample was $1.36 \pm 0.02\%$ LA. The increased acidity of prepared *Shrikhandwadi* sample might be due to the partial replacement of sugar by jaggery. Jaggery is slightly acidic in nature with pH value of 5.07 - 6.20 as reported by Nayaka *et al.* (2015). The solubility of market sample and prepared *Shrikhandwadi* sample was 90 ± 0.04 and 77.25 ± 0.06 minutes respectively. The time required for solubility of market sample was relatively more than the time required for solubility of prepared sample.

4.7.3 Comparative Hunter Colour Value Analysis of Experimental Sample and Market Sample

The 't' Table values for L*, a* and b* was found to be 61.57, 1.67 and 7.21 respectively. The results of the test revealed that the market sample and experimental sample differed significantly in terms of Hunter colour values L*, a* and b*. Colour of sample is necessary to enhance its market demand. Colour of the market sample was observed in terms of L*, a* and b* value using a Hunter lab colorimeter.

The L* value of market sample was higher (76.21 ± 0.05) than the prepared sample (29.55 ± 0.04) which might be due to brownish colour of jaggery added to *Shrikhandwadi*.

Table 19 Comparative colour value analysis of experimental sample and market sample

Sample	L*	a*	b*
Market sample	76.21 ± 0.05	8.87 ± 0.06	16.87 ± 0.05
Experimental sample	29.55 ± 0.04	7.50 ± 0.05	11.98 ± 0.09
't' value	61.57*	1.67*	7.21*

*Mean \pm SD (n=3) significantly different at $p < 0.05$

The a* value for market sample and prepared sample was 8.87 ± 0.06 and 7.50 ± 0.05 respectively. Similarly, the b* value for market sample and prepared *Shrikhandwadi* sample was 16.87 ± 0.06 and 11.98 ± 0.09 respectively.

4.7.4 Comparative Texture Analysis of Experimental Sample and Market Sample

The 't' table value for hardness, adhesiveness, springiness, cohesiveness, chewiness and guminess were found to be 2146.62, 25.28, 22.62, 21.21, 2286.49 and 16671.75 respectively. The results of 't' test revealed that the market sample and experimental sample were found to be significantly different in terms of texture profile.

From the Table 20 it can be observed that that the value for hardness for market sample and experimental sample were 48321.12 ± 0.04 and 33483.33 ± 41.9 respectively. The experimental sample was harder than the market sample. The values for adhesiveness for market sample was -24 ± 0.04 and that for experimental sample was -9.28 ± 0.06 . The value for adhesiveness was significantly for experimental sample than the market sample which might be due to the addition of jaggery in the experimental sample.

Table 20 Comparative texture analysis of experimental sample and market sample

Sample	Hardness (g)	Adhesiveness (g.sec)	Springiness (mm)	Cohesiveness (J/J)	Chewiness (N-mm)	Guminess (N)
Market sample	18465.1 ± 0.04	-24 ± 0.04	0.21 ± 0.05	0.13 ± 0.04	943.47 ± 0.03	2527 ± 0.04
Experimental sample	33483.33 ± 41.9	-9.28 ± 0.06	0.31 ± 0.06	0.24 ± 0.05	2153.70 ± 2.8	7549.79 ± 9.1
't' value	2146.62*	25.28*	22.62*	21.21*	2286.49*	16671.75*

*Mean \pm SD (n=3) significantly different at $p < 0.05$

The values for springiness for market sample and experimental *Shrikhandwadi* sample were 0.11 ± 0.05 and 0.31 ± 0.06 which show that the degree to which a product returns to its original shape after compression was lower for market sample than the experimental sample which might be due to addition of jaggery in experimental sample and the relatively more moisture present in it. The values for cohesiveness for market sample and experimental sample were 0.02 ± 0.04 and 0.24 ± 0.05 respectively and the values significantly differed from each other. From the Table 4.20 It can be revealed that the values for chewiness for market sample and experimental sample were 132.41 ± 0.03 and 2153.70 ± 2.8 respectively. The higher value of experimental sample might be due to replacement of sugar by jaggery in experimental sample. The values for

gumminess of market sample and experimental sample were 528 ± 0.04 and 7549.79 ± 9.1 respectively. The value of market sample for gumminess was significantly lower than the experimental sample.

4.7.5 Comparative Analysis of Physical Attributes of Experimental Sample and Market Sample

The 't' table value for weight, diameter and thickness of sample was found to be 2.73, 0.02 and 22.04 respectively. The results of 't' test revealed that the weight and thickness of market and experimental sample were found to be significantly different whereas the difference in diameter of the two samples was found to be non-significant.

Table 21 Comparative analysis of physical attributes of experimental sample and market sample

Sample	Wt. of sample (g)	Diameter (mm)	Thickness (mm)
Market sample	1.35 ± 0.03	17.12 ± 0.02	4.25 ± 0.04
Experimental sample	1.36 ± 0.02	17.11 ± 0.04	4.23 ± 0.03
't' value	NS	NS	NS

Table 21 depicts the physical attributes of market sample and experimental sample. The physical attributes include weight, diameter and thickness of *Shrikhandwadi* sample.

There were no significant differences between the physical attributes of market sample and experimental sample as the market sample can be made equal to the market sample.

5. SUMMARY AND CONCLUSION

5.1 Summary

The present study entitled “Preparation of goat milk *Shrikhandwadi* sweetened by jaggery” was carried out in the laboratory of Division of Animal Husbandry and Dairy Science, Rajarshree Chhatrapati Shahu Maharaj College of Agriculture Kolhapur. Under preliminary study four market samples of *Shrikhandwadi* were collected from Pune, Kolhapur, Ratnagiri and Sindhudurg and code as M₁, M₂, M₃ and M₄ which were analysed for sensory attributes, chemical composition, colour value, textural profile and physical attributes. *Shrikhandwadi* was then prepared in laboratory by using goat milk chakka and sugar was replaced by jaggery at various levels viz. 25%, 50%, 75%, 100% and 125%. The control sample was prepared by addition of sugar @ 125% of chakka. The best product was optimized based on sensory evaluation and the product thus optimized was evaluated for physico-chemical composition, colour value and textural profile.

The data thus obtained was analysed using Completely Randomized design. The optimized product was then dried in a Cabinet air dryer at 40, 50 and 60°C for 15 and 30 min. The best product was optimized on the basis of sensory evaluation. In the last part of the study the best market sample was compared with optimized product using student ‘t’ test.

5.1.1 Evaluation of Sensory Attributes, Chemical Composition, Textural Profile, Hunter Colour Value and Physical Attributes of Market Samples

5.1.1.1 Evaluation of sensory attributes of market samples

The score for colour and appearance for samples M₁, M₂, M₃ and M₄ was 7.00 ± 0.05 , 7.25 ± 0.04 , 7.30 ± 0.04 and 6.70 ± 0.04 respectively. The score for colour and appearance for market samples differed significantly. The sample M₃ received highest score and the lowest score was received by sample M₄. The score for flavour of market samples ranged from 6.80 ± 0.04 to 7.45 ± 0.03 . The sample M₃ received highest score for flavour and the lowest score was received by sample M₂. The score for body and texture for samples M₁, M₂, M₃ and M₄ was 7.35 ± 0.04 , 6.50 ± 0.03 , 7.90 ± 0.06 and 6.70 ± 0.06 respectively. The score for overall acceptability ranged from 7.55 ± 0.06 to 6.70 ± 0.05 . The maximum score was recorded for sample M₃ and the minimum score was recorded for sample M₄.

5.1.1.2 Chemical composition of market samples.

The moisture content of samples ranged from 4.31 ± 0.05 to $5.80 \pm 0.05\%$. The variation in moisture content of samples was found to be significant ($p < 0.05$). The fat content of samples M₁, M₂, M₃ and M₄ was 0.21 ± 0.04 , 0.40 ± 0.03 , 0.42 ± 0.02 and 0.10 ± 0.04 respectively whereas, protein content of samples ranged from 0.20 ± 0.04 to 2.25 ± 0.04 . The non-reducing sugar content of the samples M₁, M₂, M₃ and M₄ was 92.12 ± 0.04 , 93.50 ± 0.03 , 90.98 ± 0.04 and 92.84 ± 0.04 respectively. The non-reducing sugar content of the samples differed significantly ($p < 0.05$). The

acidity of the samples ranged from 0.70 ± 0.05 to 1.20 ± 0.04 %LA whereas the ash content of the samples ranged from 1.06 ± 0.04 to 1.24 ± 0.04 .

5.1.1.3 Texture profile analysis of market samples

The market samples were analysed for hardness, adhesiveness, springiness, cohesiveness, chewiness, guminess and resilience. The variation in texture profile of market samples was found to be non-significant except that for hardness. The hardness (g) values for the market samples were found to be in the range of 18412.08 ± 0.03 to 18525.14 ± 0.04 .

5.1.1.4 Hunter colour value of market sample

The market samples were analysed for L^* , a^* and b^* values. The L^* values of market samples ranged from 48.70 ± 0.12 to 76.21 ± 0.05 . The lower value of L^* indicates that the colour of sample is tending towards darkness. The highest value was obtained by M_3 and the lowest by M_4 . The redness-greenness (a^*) values for samples M_1 , M_2 , M_3 and M_4 were 10.72 ± 0.06 , 9.23 ± 0.05 , 8.87 ± 0.06 and 11.24 ± 0.06 respectively. The a^* values for the samples were found to be significantly ($p < 0.05$) different. The yellowness-blueness (b^*) values ranged from 16.87 ± 0.05 to 25.12 ± 0.08 . The highest value was obtained by sample M_4 and the lowest by M_3 .

5.1.1.5 Physical attributes of market samples

The samples were analysed for weight, diameter, thickness and solubility of sample. The weight of the samples M_1 , M_2 , M_3 and M_4 was 1.28 ± 0.03 , 1.25 ± 0.04 , 1.35 ± 0.04 and 1.38 ± 0.04 g respectively and the diameter of samples ranged from 16.97 ± 0.03 to 17.92 ± 0.04 mm. The variation in diameter of samples was found to be significant ($p < 0.05$). The thickness of samples M_1 , M_2 , M_3 and M_4 was also measured and it was found to be 4.20 ± 0.03 , 4.24 ± 0.04 , 4.28 ± 0.04 and 4.30 ± 0.04 mm respectively.

The time required to solubilize Shrikhandwadi sample ranged from 65 ± 0.04 to 73 ± 0.05 min and it significantly ($p < 0.05$) differed from each other.

5.1.2 Physico-chemical properties of goat milk chakka

The goat milk chakka used in present investigation contained 24.41 ± 0.17 , 11.13 ± 0.07 , 10.23 ± 0.15 , 2.06 ± 0.07 , 1.0 ± 0.20 and 1.7 ± 0.05 % total solids, fat, protein, lactose, ash and acidity respectively.

5.1.2 Effect of level of jaggery replacement to sugar on sensory, physico-chemical, texture and hunter colour value of *Shrikhandwadi*

5.1.2.1 Effect of level of jaggery replacement to sugar on sensory attributes of *Shrikhandwadi*

The score for colour and appearance of *Shrikhandwadi* ranged from 6.38 ± 0.07 to 8.31 ± 0.06 and it was significantly ($p < 0.05$) affected by the level of replacement of jaggery to sugar. The maximum score was obtained by *Shrikhandwadi* added with 50% jaggery and 75% sugar of chakka. The score for flavour of *Shrikhandwadi* for treatments J_0 , J_1 , J_2 , J_3 , J_4 and J_5 was 7.18 ± 0.05 , 8.05 ± 0.06 , 8.29 ± 0.07 , 7.88 ± 0.07 , 6.38 ± 0.07 and 5.38 ± 0.07 respectively. It was found

that the highest score was obtained by treatment J₂ which was added with 50% jaggery and 75% sugar of chakka and the lowest score was obtained by J₅ which was added with 125% jaggery of chakka.

The score for body and texture of *Shrikhandwadi* was significantly affected by the level of replacement of jaggery to sugar. The score for body and texture ranged from 5.24 ± 0.09 to 7.38 ± 0.07 . The maximum score was obtained by *Shrikhandwadi* (J₀) added with 125% sugar of chakka and the minimum score was obtained by *Shrikhandwadi* (J₅) added with 125% jaggery of chakka and it clearly indicated that jaggery was responsible for lowering the body and texture score of *Shrikhandwadi*.

The overall acceptability score for *Shrikhandwadi* for treatments J₀, J₁, J₂, J₃, J₄ and J₅ was 7.22 ± 0.04 , 7.80 ± 0.09 , 7.83 ± 0.02 , 7.59 ± 0.05 , 6.77 ± 0.08 and 5.6 ± 0.08 . The maximum score was recorded for *Shrikhandwadi* added with 50% jaggery and 75% sugar of chakka, hence it was used for further investigation.

5.1.2.2 Effect of level of jaggery replacement to sugar on chemical composition of *Shrikhandwadi*

The moisture content of *Shrikhandwadi* ranged from 6.70 ± 0.07 to $7.93 \pm 0.04\%$. The moisture content of *Shrikhandwadi* was significantly ($p < 0.05$) affected by the level of replacement of jaggery to sugar. It was observed that the fat content of the treatments J₀, J₁, J₂, J₃, J₄ and J₅ was 8.15 ± 0.02 , $8.17 \pm 0.01\%$, 8.17 ± 0.01 , 8.18 ± 0.03 , 8.20 ± 0.03 , and 8.20 ± 0.02 respectively, whereas the protein content of *Shrikhandwadi* ranged from 13.12 ± 0.05 to $13.25 \pm 0.02\%$. The protein content of *Shrikhandwadi* for treatments J₀, J₁, J₂, J₃, J₄ and J₅ was 13.12 ± 0.05 , 13.15 ± 0.04 , 13.13 ± 0.02 , 13.20 ± 0.03 , 13.23 ± 0.01 and 13.25 ± 0.02 per cent respectively. The results showed that the treatment J₅ had significantly higher protein content than all other treatments.

The reducing content of *Shrikhandwadi* of treatments J₀, J₁, J₂, J₃, J₄ and J₅ was 8.65 ± 0.05 , 10.71 ± 0.01 , 12.58 ± 0.04 , 14.30 ± 0.04 , 16.08 ± 0.04 and 18.23 ± 0.07 per cent respectively.

The non-reducing sugar content of *Shrikhandwadi* ranged from 50.47 ± 0.07 to 61.38 ± 0.08 . The maximum non reducing sugar content was observed for treatment J₀ (*Shrikhandwadi* added with 125% sugar) and minimum for J₅ (*Shrikhandwadi* added with 125% jaggery).

The ash content of *Shrikhandwadi* ranged from 2.06 ± 0.03 to $2.24 \pm 0.02\%$. The ash content of *Shrikhandwadi* was significantly affected by the level of replacement of jaggery to sugar. The ash content for treatments J₀, J₁, J₂, J₃, J₄ and J₅ was 2.06 ± 0.03 , 2.14 ± 0.02 , 2.15 ± 0.02 , 2.18 ± 0.03 , 2.20 ± 0.03 and 2.24 ± 0.02 respectively.

5.1.2.3 Effect of level of jaggery replacement to sugar on solubility and acidity of *Shrikhandwadi*

The solubility time required for *Shrikhandwadi* ranged from 73.00 ± 0.06 to 85.25 ± 0.05

min. The minimum time was required by *Shrikhandwadi* prepared by addition of sugar @ 125% of chakka. The maximum time required for solubility of *Shrikhandwadi* was recorded for the formulation containing 125% jaggery of chakka.

The acidity of *Shrikhandwadi* for treatments J₀, J₁, J₂, J₃, J₄ and J₅ was 1.31 ± 0.02 , 1.33 ± 0.02 , 1.36 ± 0.02 , 1.39 ± 0.01 , 1.42 ± 0.01 and $1.44 \pm 0.01\%$ respectively. The highest acidity was recorded for treatment J₅ ($1.44 \pm 0.01\%$) and lowest by treatment J₀ ($1.31 \pm 0.02\%$) The influence of experimental treatments on acidity content of *Shrikhandwadi* was significant ($p < 0.05$). All the treatment samples differed significantly among themselves.

5.1.2.4 Effect of level of jaggery replacement to sugar on Hunter colour value of *Shrikhandwadi*

The level of replacement of sugar by jaggery had significant ($p < 0.05$) effect on lightness, redness and yellowness values of *Shrikhandwadi*. The lightness values decreased from 58.63 ± 0.08 to 21.83 ± 0.04 . The highest value was found for treatment J₀ and lowest for treatment J₅. The redness-greenness (a^*) values ranged from 0.48 ± 0.02 to 8.22 ± 0.02 . The values differed significantly ($p < 0.05$) from J₀ to J₅. The highest a^* value was observed for treatment J₅ and the lowest for treatment J₀.

The yellowness-blueness values of *Shrikhandwadi* decreased from 15.23 ± 0.03 to 8.38 ± 0.06 . The b^* value of the different treatments of *Shrikhandwadi* was significantly ($p < 0.05$) affected by the level of replacement of sugar by jaggery. The highest value was recorded for treatment J₀ (15.23 ± 0.03) and lowest for treatment J₅ (8.38 ± 0.06).

5.1.2.5 Effect of level of jaggery replacement to sugar on texture profile of *Shrikhandwadi*

The hardness of *Shrikhandwadi* ranged from 18385.75 ± 39.6 to 44228.71 ± 87.6 g. The values of obtained for adhesiveness of *Shrikhandwadi* ranged from -23.47 ± 0.04 to -1.92 ± 0.06 g.sec whereas the values for springiness of *Shrikhandwadi* ranged from 0.22 ± 0.05 to 0.41 ± 0.05 . The values obtained for springiness for treatment J₀, J₁, J₂, J₃, J₄ and J₅ were 0.22 ± 0.05 , 0.23 ± 0.04 , 0.31 ± 0.06 , 0.35 ± 0.05 , 0.38 ± 0.04 and 0.41 ± 0.05 respectively.

The values for cohesiveness ranged from 0.15 ± 0.05 to 0.35 ± 0.06 . The highest value was obtained for treatment J₅ and lowest score was obtained for treatment J₀. The results revealed that the values for cohesiveness significantly ($p < 0.05$) differed from each other. The values obtained for chewiness of *Shrikhandwadi* for treatment J₀, J₁, J₂, J₃, J₄ and J₅ were 955.32 ± 4.7 , 1699.63 ± 3.2 , 2153.70 ± 2.8 , 3205.64 ± 2.04 , 4594.33 ± 1.2 and 5009.54 ± 3.6 respectively. The values for chewiness were significantly ($p < 0.05$) affected by the level of replacement of jaggery to sugar.

The values obtained for guminess of *Shrikhandwadi* ranged from 2914.22 ± 15.0 to 15648.24 ± 4.0 . The values obtained for chewiness of *Shrikhandwadi* for treatment J₀, J₁, J₂, J₃, J₄

and J_5 were 2914.22 ± 15.0 , 5295.97 ± 8.1 , 7549.79 ± 9.1 , 9613.67 ± 8.1 , 13040 ± 9.4 and 15648.24 ± 4.0 respectively.

5.1.3 Effect of Temp-time combination on sensory attributes of *Shrikhandwadi*

The temperature-time combination required for drying of *Shrikhandwadi* significantly affected the colour and appearance of *Shrikhandwadi*. The score for colour and appearance was highest for treatment T_1 (*Shrikhandwadi* dried at 40°C for 15 min) and lowest score was obtained by treatment T_6 (*Shrikhandwadi* dried at 60°C for 30 min). The score for flavour for treatments T_1 to T_6 was 8.21 ± 0.04 , 8.20 ± 0.03 , 8.04 ± 0.05 , 7.84 ± 0.02 , 7.70 ± 0.02 , 7.50 ± 0.06 respectively. The highest score was obtained by *Shrikhandwadi* dried at 40°C for 15 minutes and lowest by *Shrikhandwadi* dried at 60°C for 30 minutes.

The score for body and texture ranged from 8.24 ± 0.02 to 6.55 ± 0.06 . The maximum score for body and texture was recorded for *Shrikhandwadi* dried at 40°C for 15 minutes. The minimum score was obtained by *Shrikhandwadi* dried at 60°C for 30 minutes. The score for overall acceptability of *Shrikhandwadi* was significantly ($P < 0.05$) affected by temperature-time combination during drying. The score for overall acceptability ranged from 8.23 ± 0.02 to 7.03 ± 0.06 .

5.1.4 Comparison of Experimental Sample with Market Sample.

The product thus optimized was compared with the market sample for sensory attributes, physico-chemical composition, Hunter colour value and texture profile.

5.1.4.1 Comparative sensory analysis of experimental sample and market sample

The score for colour and appearance for market sample and experimental sample was 7.86 ± 0.04 and 8.31 ± 0.06 respectively. It was revealed that the score obtained by the experimental sample was more than of the market sample. Similarly maximum and significant higher score for flavour and overall acceptability was recorded for experimental sample. However, the body and texture score of market and experimental sample was non-significant

5.1.4.2 Comparative physico-chemical composition of experimental sample and market sample

The moisture content of market sample was 5.20 ± 0.04 which was significantly ($p < 0.05$) lower than that of prepared sample was (7.19 ± 0.06). However, the protein content of experimental sample was significantly higher than the market sample, which indicates the nutritional importance of experimental sample. The protein and fat content in experimental product was 13.18 ± 0.02 and 8.20 ± 0.02 respectively. The non-reducing sugar content of market sample and prepared sample was 90.98 ± 0.04 and 57.18 ± 0.06 respectively. The result reveals that the non-reducing sugar content of market sample was higher than that of prepared sample. The ash content of market sample and prepared sample was 1.15 ± 0.03 and 2.15 ± 0.02 respectively. The ash content of market sample was found to be greater than the prepared *Shrikhandwadi* sample.

The acidity of market sample was 0.73 ± 0.05 and that of prepared sample was 1.36 ± 0.02 whereas the time required for the solubility of market sample and prepared Shrikhandwadi sample was 65 ± 0.04 and 77.25 ± 0.06 minutes respectively. The time required for solubility of market sample was relatively more than the time required for solubility of prepared sample.

5.1.4.3 Comparative colour value analysis of experimental sample and market sample

The L^* value of market sample was higher (76.21 ± 0.05) than the prepared sample (29.55 ± 0.04). The a^* value for market sample and prepared sample was 8.87 ± 0.06 and 7.50 ± 0.05 respectively. Similarly, the b^* value for market sample and prepared *Shrikhandwadi* sample was 16.87 ± 0.06 and 11.98 ± 0.09 respectively.

5.1.4.4 Comparative texture analysis of experimental sample and market sample

The value for hardness for market sample and experimental sample were 18465.12 ± 0.04 and 33483.33 ± 41.9 respectively and it was found that experimental sample had more value due to chewiness and gumminess in the product due to the utilization of jaggery. The values for adhesiveness for market sample was -46 ± 0.04 and that for experimental sample was -9.28 ± 0.06 . The values for springiness for market sample and experimental *Shrikhandwadi* sample were 0.21 ± 0.05 and 0.31 ± 0.06 . The values were significantly different for market sample and experimental sample.

The values for cohesiveness for market sample and experimental sample were 0.13 ± 0.04 and 0.24 ± 0.05 respectively. The values for chewiness for market sample and experimental sample were 943.47 ± 9.1 and 2153.70 ± 2.8 respectively.

The values for guminess of market sample and experimental sample were 2527 ± 0.04 and 7549.79 ± 0.06 respectively. The value of market sample for guminess was significantly lower than the experimental sample.

5.1.4.5 Comparative analysis of physical attributes of experimental sample and market sample

The weight of market sample was 1.35 ± 0.04 and that of experimental sample was 1.40 ± 0.02 g. The values for diameter of market sample and experimental sample were 17.92 ± 0.04 and 17.10 ± 0.04 mm respectively. Further the thickness measurements were 4.25 ± 0.04 and 5.20 ± 0.03 mm for market sample and experimental sample respectively. The market sample was thicker than the experimental sample.

5.2 Conclusions

From the present study it is concluded that,

1. The best quality *Shrikhandwadi* could be prepared by addition of jaggery@ 50% and sugar @75% of chakka.
2. The optimized *Shrikhandwadi* scored 8.31 ± 0.06 , 8.29 ± 0.07 , 6.90 ± 0.06 and 7.83 ± 0.02 for colour and appearance, flavour, body and texture and overall acceptability respectively. The

optimized product contained $7.19 \pm 0.06\%$, 8.17 ± 0.01 , 13.18 ± 0.02 , 12.58 ± 0.04 , 57.18 ± 0.08 and 2.15 ± 0.02 moisture, fat, protein, lactose, non-reducing sugar and ash respectively.

3. The best quality of *Shrikhandwadi* could be obtained by drying the Shrikhandwadi at 40°C for 15 minutes.

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8. VITAE

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