STUDIES ON EFFECT OF NON-NUTRITIVE SWEETENERS ON QUALITY OF SHRIKHAND

THESIS SUBMITTED TO THE
NATIONAL DAIRY RESEARCH INSTITUTE
(DEEMED UNIVERSITY)
IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR
THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY
IN
DAIRYING
(DAIRY TECHNOLOGY)

BY

MURLIDHARA.N.S
B.Tech (Dairy Technology)

DAIRY TECHNOLOGY SECTION
NATIONAL DAIRY RESEARCH INSTITUTE
(I.C.A.R)
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BANGALORE – 560030, INDIA

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KARNAL (HARYANA)

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Approved By

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CERTIFICATE

This is to certify that the thesis entitled, **'STUDIES ON EFFECT OF NON NUTRITIVE SWEETENERS ON QUALITY OF SHRIKHAND '** submitted by **Mr.Murlidhara.N.S,** towards the partial fulfillment of the requirement for the award of the degree of **MASTER OF TECHNOLOGY IN DAIRYING (DAIRY TECHNOLOGY)** of the **NATIONAL DAIRY RESEARCH INSTITUTE (Deemed University), Karnal (Haryana), INDIA,** is a bonafide research work carried out by him under my supervision and guidance and no part of the thesis has been submitted for any other degree or diploma.

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DEDICATED

TO

MY PARENTS

सारांश

उपभोक्ता के निम्न केलोरी भोजन की आवश्यकता एवं पी एफ ए (PFA) द्वारा बनाए गए संशोधनों को ध्यान में रखते हुए, चुने गए कृत्रिम मिठासों का उपयोग करते हुए श्रीखण्ड़ के उत्पादन की तकनीकी के मानकीकरण के लिए यह अनुसंधानात्मक प्रयत्न किया गया । 9.0 % एस एन एफ (SNF) युक्त मलाई रहित दूध का उपयोग कर बनाया गया चक्का श्रीखण्ड़ के उत्पादन के लिए उपयुक्त पाया गया । दूध में उच्च स्तर एस एन एफ (SNF) के प्रयोग के परिणामस्वरुप श्रीखण्ड में धूली सुवास एवं दानेदार रचना देखने में आई । प्रयत्न किए गए दो तरह के अम्लता स्तर वाले चक्का मे, श्रीखण्ड के उत्पादन के लिए 1.6 एल ए (LA) युक्त चक्का अधिक अनुकूल पाया गया । श्रीखण्ड के उत्पादन के लिए 65 ग्रा0/100 ग्रा0 चीनी मिश्रित चक्का स्वीकार्य था । कृत्रिम मिठास जैसे एसपरटेम (aspartame) सेच्चरीन (saccharine) एवं सुक्रालोस (sucralose) का मिठास तत्व के रुप में मिलाने का प्रयत्न किया गया । अत्याधिक अनुमति प्राप्त स्तर पर भी चीनी मिलाकर बनाए गए श्रीखण्ड की तुलना में प्रयोग किया गया कोई भी मिठास इच्छित मिठापन नहीं दे पाया । चीनी के भिन्न-भिन्न स्तर के साथ प्रत्येक कृत्रिम मिठास को मिलाकर श्रीखण्ड में इच्छित मिठापन पाने का प्रयत्न किया गया । इसके परणिाम ने यह दिखाया कि 50% चीनी के साथ 750 पी पी एम (ppm)सुक्रालोस, 75% चीनी के साथ 500 पी पी एम (ppm)सेच्चरीन, 75% चीनी के साथ 200 पी पी एम(ppm) एसपरटेम श्रीखण्ड के उत्पादन के लिए अधिक स्वीकार्य पाया गया । नियंत्रित श्रीखण्ड एवं चुने गए चीनी के स्तर के साथ कृत्रिम मिठास का उपयोग कर बनाए गए नमूनों के बीच सेंसोरी स्कोर्स में कोई प्रमुख भिन्नता दिखाई नहीं दी । 65^0 से पर 15 मिनट तक थरमाइज़ किए गए नमूने 37^0 से पर 5 दिन तक टिकाऊ थे एवं प्रशीतित तापमान (6-8^0 से) पर 30 दिन तक टिकाऊ थे । सुक्ष्मजैविकी अध्ययन यह इंगित करता है कि 37^0 से पर 5 दिन के अन्त में खमीर एवं मोल्ड़ की गणना < 30/ग्रा0 एवं प्रशीतित तापमान पर 30 दिन के संग्रहण के अन्त में < 30/ग्रा0 थी । इसी तरह कोलिफार्म (coliform) गणन क्रमश: < 30/ग्रा0 एवं < 30/ग्रा0 था । रासायनिक मिश्रण यह दर्शाता है कि कृत्रिम मिठास का उपयोग कर बनाए गए श्रीखण्ड के किसी भी नमूने में टी एस (TS) पी एफ ए मानक के अनुरुप था । किन्तु, नमूनों में वसा, प्रोभिज़न, सुक्रोस एवं एश तत्व मानक के अनुरुप थे ।

ABSTRACT

Considering the need for low calorie foods and latest amendments made by PFA, the present investigation was undertaken to standardize the technology for production of *Shrikhand* by using selected artificial sweeteners. Chakka made by using skim milk containing 9.0% SNF was found suitable for production of *Shrikhand.* Use of higher level of SNF in milk resulted in powdery flavor and grainy texture in *Shrikhand.* Between the two acidity levels in chakka tried, 1.6% LA in chakka was found most suitable for *Shrikhand* production. Addition of cane sugar at 65gms/100gm chakka was best accepted in *Shrikhand* production. The artificial sweeteners like aspartame, saccharine and sucralose were tried to incorporate in *Shrikhand* as sweetening agents. Even at maximum permitted levels, none of sweeteners tried, could able to impart desired sweetness in *shrikhand* equivalent to that made by using 65% cane sugar (on chakka basis). In order to obtain desirable sweetness in *Shrikhand*, the individual artificial sweeteners (at maximum permitted levels) in combination with different levels of cane sugar were tried. The results indicate that, Sucralose at 750ppm with 50% of cane sugar, saccharine at 500ppm with 75% cane sugar , aspartame at 200ppm with 75% of cane sugar were found most acceptable levels for production of *Shrikhand* . No significant difference in sensory scores were observed between the samples made by using artificial sweeteners in combination with selected levels of sugar and control *Shrikhand.* The *Shrikhand* samples thermized at 65^0C for 15min was found to have the shelf life of 5 days at 37^0C and 30 days at refrigerated temperature (6 - 8^0C). The microbiological studies indicate that, the yeast and mold counts were <30/gm at the end of 5days at 37^0C, and <30/gm at the end of 30days of storage at refrigerated temperature. The corresponding coliforms counts were <30/g and <30/g respectively. The chemical composition shows that, none of the *Shrikhand* samples prepared by using artificial sweeteners had TS conforming to PFA standards. However, the fat, protein, sucrose and ash contents of the samples conformed to the standards.

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1.0 INTRODUCTION

The use of fermented dairy products has been an essential part of our food consumption since ancient times. These products vary considerably in composition, flavour and texture according to the nature of fermenting organisms, the type of milk used and the manufacturing process. (Kosikowski, 1977). In India, an estimated 50 to 55 percent of the milk produced, is converted into a variety of traditional milk products, using processes such as coagulation (heat and / or acid), desiccation and fermentation. (Aneja, 1997)

The name Shrikhand is probably derived form the Sanskrit word "Shrikarini" meaning a curd preparation with the addition of sugar, flavouring materials, dried fruits etc. Shrikhand is a semi-solid, sweetish-sour, wholesome, indigenous fermented milk product of western India (Desai and Gupta, 1986). It is popular mainly in the states of Gujarat. Maharashtra, Karnataka and some part of north India. Traditionally it is prepared from dahi (Indian fermented milk) by isolating the milk solids "chakka" through straining. kneading chakka with sugar and added flavouring materials. Shrikhand is considered as the Indian analogue to western quarg (Patel and Abdel - Salam, 1986).

Sweetness is one of the most important taste sensations in humans and in many animal species as well. It has been observed that most of the food habits today involve the sweet taste in some other form. Several food ingredients stimulate the sensation of sweetness by interacting with taste receptor cells in mouth. Sucrose has been the main source of sweetness in prepared foods arid in the food industry. The sugar also helps in obtaining desired body and texture Food industry is constantly on the look out for alternate sweeteners. The reason for this search is two fold namely, increased calorie consciousness of the consumer who wants to lower his calorie intake, and increasing number of consumers who are diabetic. Therefore, a sucrose substitute should provide low calorie and should have insulin independent metabolism.

In recent years the manufacturers are diversifying the production to include the specialty items that cater to specific targeted population. Diabetic friendly traditional sweet is a new category for such products, the production of which is being contemplated by many enterprising manufacturers. Today, with much-improved blends, the market share of artificial sweeteners is much larger. It will continue to rise as sweeteners continue to improve. (Arora *et. al.*, 2001)

According to Calorie Control Council (2004), an ideal sweetener should have the same sweetness as sucrose. In addition it should be odourless, colourless, stable and readily soluble in food system. It should be functional, economically feasible, noncarcinogenic and non toxic.

According to Ministry notification amending the PFA Rules 1955 and issued by the of Health and Family Welfare in 2006 the use of artificial sweeteners has been allowed in food items as per the limits prescribed and under proper label declarations. Present notification permits use of artificial sweeteners like aspartame, sucralose and saccharin within prescribed limits in milk based foods.

Use of artificial sweeteners has been allowed by PFA for the first time in sweets like halwa, khoya, burfi, rasgolla, gulabjamun and other milk products. Since, the application of artificial sweeteners in indigenous dairy products is new, a quantitative information on the sweeteners in dairy systems is required.

Considering the need of the milk products consumers and latest amendments in PFA rules, there is a considerable scope to study the effect of incorporation of artificial sweeteners on the sensory parameters. Since no information is available on use of these sweeteners in Shrikhand this project study was taken up with the following objectives.

1. To screen the available and permitted artificial sweeteners for use in the production of *Shrikhand*
2. To standardize the technology for production of *Shrikhand* by using selected artificial and
3. To study the shelf life of the product.

2.0 REVIEW OF LITERATURE

In India, production of traditional sweets exists mostly in the unorganized sector in the form of small-scale manufacturers spread all over the country. Consumption of sweets is an integral part of Indian dietary system. An estimated 54% of India's milk production is converted into products both traditional and western, with 50% share of traditional products (Vaswani, 2002). But in recent years the manufacturers are diversifying the production to include the speciality items that cater to specific targeted population. Diabetic friendly traditional sweet is a new category for such products, the production of which is being contemplated by many enterprising manufacturers. Today, with much improved blends, the market share of artificial sweeteners is much larger. It will continue to rise as sweeteners continue to improve. (Arora et. aI. 2001)

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Shrikhand a lactic fermented and sweetened milk product is widely popular in western parts of India. It is prepared by lactic acid coagulation of milk and expulsion of whey from curd, followed by blending of cream, sugar, flavour and spices. Nearly 30–50% sugar is added to chakka as sweetening agent. This not only contributes to the sweetness, but also contributes to body & texture and calories to the product. With increased consumer awareness regarding calorie intake, there is a scope for use of non-nutritive sweeteners in

milk based foods. Information available on various aspects of *Shrikhand* manufacture, and physico-chemical properties of selected artificial sweeteners and their application in food preparation particular milk based are reviewed in this chapter.

2.1 SHRIKHAND

2.1.1 Definition: *Shrikhand* is a semi-soft, sweetish-sour, whole milk product prepared from lactic fermented curd (Sukumar De, 1980). The curd (dahi) is partially strained through a cloth to remove the whey and thus produce a semisolid mass called chakka, the basic ingredient for *Shrikhand*. This chakka is mixed with the required amount of sugar and natural flavorings such as nuts, cardamom, saffron and other spices may be added. It should not contain any coloring and artificial flavoring substances (Aneja *et al*., 2002)

According to PFA (2006), *Shrikhand* is a product obtained from chakka or skimmed milk chakka to which milk fat is added. It may contain fruits. nuts, sugar, cardamom, saffron and other spices .It shall not contain any added colouring and artificial favouring substances. It shall conform to the following specification namely. total solids (per cent by weight) not less than 58 , milk fat (on dry matter) per cent by weight not less than 8.5, milk proteins (on dry matter) per cent by weight not less than 10.5, titratable acidity (as lactic acid) per cent by weight not more than 1.4, sucrose (on dry basis) percent by weight not more than 72.5, total ash(on dry basis) per cent by weight not more than 0.9 In case of fruit *Shrikhand*, it shall contain milk fat (on dry basis) per cent by weight not less than 7.0 and milk protein (on dry basis) percent by weight not less than 9.0.

2.1.2 Production of Shrikhand:

For *Shrikhand* making, cow or buffalo milk is widely preferred. The majority of characteristics of finished product are generated by composition attributes of raw milk.

2.1.2.1 Type and Composition of Milk

The compositional variation between cow and buffalo milk influences the quality of curd. The curd prepared from buffalo milk is firmer than that from cow milk. The higher curd tension of buffalo milk curd has been attributed to the higher levels of SNF (Ganguli and Menon, 1971) and calcium (Yadav and Singh 1973; Sindhu and Roy, 1973). Higher rate of syneresis in rennet curd prepared from buffalo milk was observed (Ganguli, 1974). This may held true for lactic curd from buffalo milk. Upadhyay and Dave (1977) reported that, use of standardized milk in dahi making yielded a smooth body, but noticed higher fat losses in whey. Patel and Chakraborty (1985) observed a loss of 0.20 to 0.35 percent fat in whey obtained from standardized milk (5% fat) curd. Aneja *et al*. (1977), Upadhyay (1981) and Miyani (1982) preferred the use of skim milk to whole milk for making dahi for *Shrikhand* preparation. The advantages of using skim milk are (i) the elimination of fat losses in whey, (ii) the faster moisture expulsion from the curd and (iii) the less moisture retention in the curd.

Reconstituted skim milk has been found as an effective alternative to fresh skim milk for *Shrikhand* making (Patel and Chakraborty, 1985). Higher SNF in milk gives a curd of firm body, reduces curd loss in whey resulting in a higher yield. Aneja *et al*. (1977) reported 2 percent increase in Chakka yield when SNF level was increased from 10 to 11 percent. Powdery flavour was observed in the finished product, with a further increase in SNF level. Karthikeyan *et al*. (2000) studied the effect of replacement of buffalo skim milk by sweet buttermilk on storage changes of *Shrikhand*. They found that there was a significant increase in titratable acidity and decrease in pH at and above 50 percent replacement. Geran and Barbind (2001) showed that adding 5 percent sour whey concentrate in Chakka increased the yield of *Shrikhand* by 5 percent over traditional method without causing any change in physical attributes of *Shrikhand*. However, any further increase in level of whey concentrate adversely affected the flavour, consistency, body and taste.

Vagdalkar.*et al*. (2002) studied the production and overall acceptability of consumers of *Shrikhand* prepared by cocoa powder and papaya pulp. Samples that contained 5 percent cocoa powder and 60 percent papaya pulp had the highest score on 5-point hedonic scale.

2.1.2.2 Heat Treatment of Milk

Heat treatment of milk not only creates a near sterile environment for the growth of lactic acid bacteria, but also reduces curd tension. The heat treatment of milk results in the destruction of certain heat labile inhibitors as well as many of the competing microorganisms that are present in the raw milk (Babel, 1959; Speck, 1962; Parry, 1974; Feldstein and Westhoff, 1979). Severe heat treatment can result in alterations of proteins in milk to favour the growth and activity of starter cultures. One such alteration, which favors the growth and activity of starter cultures, is the production of free sulphydral groups (Davies *et al*., 1978). Aneja *et al*. (1977) observed an increase in the yield of Chakka by 5 percent when the milk was heated at 90°C for 16 sec, as compared to heat treatment of 70°C for 16 sec. This increase in the yield of Chakka was attributed to the precipitation of heat denatured whey protein. Ott *et al*. (1979) observed that heating of milk at 90°C for 30 min increased the yield of quarg (a western product resembling Chakka) by 15 to 20 percent due to precipitation of a lactalbumin and β-Iactoglobulin, and it was claimed that consistency as well as nutritive value and hygienic quality of quarg were improved thereby. Heating of milk to 80 to 87°C or 96°C for 0.5 to 1.0 min considerably increased the yield of quarg accompanied by a corresponding reduction of about 25 to 30 percent in whey protein content of the quarg whey.

2.1.2.3 Fermentation:

Lactic fermentation is the key process behind the curd formation. Besides, acid curd required for several coagulated dairy products has also been prepared by the method of direct acidification. Several operational parameters control the quality of curd formed by either of these processes. Lactic fermentation essentially implies the process of a gradual increase in

developed acidity as a result of lactose metabolism by lactic bacteria. The use of right type of culture is essential for the manufacture of *Shrikhand*. In case of lactic fermentation of milk, starter culture microorganisms are selected on the basis of their ability to utilize lactose and produce lactic acid and or flavour compounds in a manner characteristic of a particular fermented product. The use of non-contaminated lactic cultures in a desired state of activity is an essential pre-requisite for the manufacture of fermented milk including *Shrikhand*. Aneja *et.al.* (2002) suggested the use of a mixed culture containing *Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* subsp. *diactylactis leuconostoc Lactococcus lactis* subsp. *cremoris* in the ratio of 1:1:1 for the production of good quality *Shrikhand*.

Different aspects of manufacture of *dahi* have been studied and reported (Srinivasan and Banerjee, 1946; Laxminarayana and Iya, 1952; Rangappa and Achaya, 1974; Gandhi and Jain, 1977; Chakraborty *et al.,* 1981). Relatively less attention has been paid to the formation of lactic acid curd for *Shrikhand* manufacturing. The lactic acid curd best suited for *Shrikhand* making must attain a desired level of firmness, acidity and aromatic traits along with an optimum rate of whey drainage. The quality of lactic acid curd, in turn, is influenced by the type, composition and treatment of milk, type of starter culture and incubation conditions

Traditionally, back slopping, i.e., use of a portion of previous day's curd or whey is employed for setting the curd. However, uncontrolled fermentation is one of the problems associated with this practice. The basic role of starter culture is to supply large number of desirable microorganism in their optimum state of activity. This is achieved by promoting the growth of starter organisms under optimum conditions of incubation time and temperature, and by ensuring nutritional supply in the culture media (Hammer and Babel, 1957; Foster *et al*., 1958; Lloyd, 1971; Tamime and Deeth, 1980). The propagation of starter culture in dairy industry is scaled up through the stages of mother culture, intermediate culture and bulk culture for ultimate utilization in the manufacture of fermented milk products. This procedure helps to obtain a desired level of

activity, but propagation of cultures in laboratory is not entirely free from problems of contamination, loss of activity, mutation of strains Loss of strain balance and phage attack (Lloyd, 1971; Cox and Lewis, 1972; Lawrence *et al*., 1976). Advances in starter culture technology include the production of DVS (Direct vat set) cultures, thus eliminating the need for propagation at dairy laboratory level (Lloyd, 1971; Lawrence and Pearce, 1972: Cox and Lewis, 1972; Chapman, 1978).

2.1.2.4 Dahi and *Shrikhand* Starters

Traditionally, the use of previous day's curd or whey for setting curd has resulted in the propagation of naturally well balanced mixed type multiple strain culture that is required to produce about 1 percent lactic acid acidity within a period of 12 to 15 h at an incubation temperature of 25° to 30°C.

2.1.2.4.1 Dahi Starters

In India, mixed cultures of unknown composition are being used for the preparation of dahi under market and household conditions. Laxminarayana *et al*. (1952) reported the presence of *S. thermophilus*, *L. lactis, L. faecalis, L. dextranicum, Lb. bulgaricus, Lb. casei* and *Lb. brevis* in market and homemade samples. Sheih *et al*. (1970) found that 78.9 percent of dahi flora was of *Streptococci* and 17.5 percent were of *Lactobacilli.* The Indian Standard Specifications (1980) specifies two types of dahi starters (i) Mesophilic starters like, *L. lactis, L. lactis* subsp. *diacetylactis* and *L. cremoris* either single or in combination with or without *Leuconostoc* spp. for sweet dahi preparation, and (ii) Thermophilic starters like, *Lb. bulgaricus, Lb. casei, Lb. acidophilus* and *S. thermophilus* along with the above mentioned mesophilic starters for sour dahi preparation. No mention is made about the ratio of these cultures. Baisya and Bose (1974) prepared dahi with *S. thermophilus* (ST). The use of ST and L.B in 1:1 ratio was advocated by Baisya and Bose (1975) and Garg and Jain (1980). The improved quality of dahi was prepared with *L. lactis* subsp*. diacetylactis* mutant by Bhatt (1976). A LF40 culture (consisting of *L. lactis, L. lactis ssp*

diacetylactis. L. cremoris and *Leuconostoc* spp.) was used for preparation of dahi (Ghosh and Rajorhia, 1990). There was a report of using *L. lactis* alone for the manufacture of sweetened dahi (Pandey, 1985). Rajorhia (2000) suggested the use of mixed starter composed of *L. lactis* and *L. lactis* subsp. *diacetylactis,* due to its good flavour in the finished product.

2.1.2.4.2 *Shrikhand* Starters

Putambekar (1968) made use of *L. cremoris* or L. lactis at the rate of 1 to 2 percent to obtain a well-set curd for *Shrikhand* preparation. Gandhi and Jain (1977) used mixed culture containing *L. lactis, L. lactis* ssp *diacetylactis* and *L. cremoris* in a ratio of 1:1:1. Whaghmare *et al*. (1978) tried six different strains of *Lb. bulgaricus, Lb. casei, L. lactis* ssp *diacetylactis Lb. acidophilus, L. lactis* and *L. cremoris* for *Shrikhand* making. The product prepared with former three strains was reported to have superior flavour and taste. The later three produced good body characteristics in the finished product. Aneja *et al*. (1977)

Upadhyay (1981) and Miyani (1982) used mixed cultures for *Shrikhand* making. Patel (1982) suggested the use of mixed culture 'YH' consisting of S*. thermophilus* and *Lb. bulgaricus* as a mean to reduce the curd setting time to 3 h. Rao (1992) showed that use of BD4 (mixed culture of *L. cremoris, L lactis* ssp. *diacetylactis* and *Leuc. mesenteroids* subsp. *cremoris)* at high incubation temperature led to an inferior quality curd, without reducing the coagulation time. Aneja *et al*. (2002) mentioned about the use of mixed culture composed of *Lactococcus lactis, L. lactis* subsp. *diacetylactis Leuconostoc, L. cremoris* (1: 1: 1) or yoghurt culture for manufacture of *Shrikhand* in the organized sector.

2.1.3 Flavour Development of Fermented Dairy Products

The development of sufficient amount of desirable flavour and aroma is important in the manufacture of fermented milk products. Diacetyl is an important contributor to the flavour of the cultured dairy products. It is the major flavour component although a number of other components are also present

(Parker and Elliker, 1953). One general approach to enhance the flavour involves the use of modified cultures and culturing techniques. Some degree of success has been achieved by incorporating high diacetyl producing strains of citrovorum and L.*lactis* ssp *diacetylactis.* But the mixed strain cultures have shown that it is very difficult to realise the consistency in flavour production under routine plant propagation programme. Synthetic butter culture flavour concentrates for butter, cottage cheese; sour cream and buttermilk were prepared by Lindsay *et al*. (1967). Flat components included in the formulation were diacetyl, acetaldehyde, dimethyl sulfide, acetic acid and lactic acid. Products, flavoured with culture flavour concentrates was found to possess a flavour very similar to that produced by natural butter cultures. It was also found that the intensity of the culture flavour could easily be manipulated by simply changing the diacetyl concentration in the respective product formulation. In general, levels of diacetyl from 0.5 to 1.0 ppm here found to give mild intensities, 1.25 to 2.0 ppm intermediate intensities and from 2.25 to 3.00 ppm pronounced intensities of culture flavour.

2.1.4 Amount of Inoculum, Time and Temperature of Incubation

The conditions during incubation should be selected to ensure a desirable balance between lactic acid and aroma producing bacteria (Hammer and Babel, 1957). Active culture added at the rate of 1.0 percent and incubated at 21 to 22°C yields a firm curd with acidity of 0.8 to 1.0 percent lactic acid and delicate flavour in 14 to 16 h (Baisya and Bose, 1975). Gandhi and Jain (1977) inoculated buffalo milk having 4.0 percent fat with 5.0 percent mixed starter culture and incubated at 30°C for 14 to 16 h to a pH of 4.6 to 4.8. Ingle and Joglekar (1974) inoculated boiled milk with 2.0 percent mixed starter culture and incubated at 34°C for 16 h to obtain a dahi with desirable texture and pleasing aroma. Aneja *et al*. (1977) used a mixed dahi culture at the rate of 5.0 percent and incubated it at 30°C for 8 h to obtain a curd having an acidity of 0.8 to 1.0 percent. Upadhyay (1981) employed a mixture of *S. lactis* and *S. diacetyl lactis* (1:1) at a rate of 2.0 percent and incubated it at 28.3°C for 9 hr to obtain a satisfactory curd with 0.85 percent acidity. Patel (1982) inoculated buffalo milk

with a mixed 'YH' culture at the rate of 1.5 to 2.0 percent and incubated at 42°C for 4 h to obtain an acidity of 0.9 to 1.0 percent. Magy (2002) isolated some strains of thermophilic culture from market dahi samples for short-set method of dahi preparation, which coagulated milk within 4 h at an incubation of 42°C.

2.1.5 Whey removal

Expulsion of whey influences the body and texture in the finished product Expulsion of whey mainly depends on moisture binding tendency, and is influenced by the type and composition of milk, heat treatment and level of Ca^{++}. It is also a function of pH of the coagulum (Patel *et al*., 1972). Pearse *et al*. (1985) attributed the inhibition of syneresis caused by heat to the complex formation between β-Iactoglobulin and K-casein.

Traditionally, draining of whey is done by hanging the curd in muslin cloth for six hours or more, until the draining apparently ceases (Putambekar, 1968; Ingle and Joglekar, 1974; Gandhi and Jain, 1977). At household level, the process of draining out the whey is hastened by the use of a sand/straw/saw dust bed (Aneja *et al*., 1977). This method is not only unhygienic but also lead to the variation from batch to batch in finished product. Rapid whey drainage provides better control on acidity thereby saving of time. Aneja *et al*. (1977) and Patel (1982) employed a batch-to-batch type basket centrifuge for rapid remove of whey. Upadhyay *et al*. (1975) and Desai *et al*. (1987) used a batch type vacuum whey separator for rapid expulsion of whey from curd. Sharma and Reuter (1993) reported that the use of ultrafiltration for concentration of curd would increase the yield of chakka by 23 percent over traditional methods.

Chakka, the base product for *Shrikhand* manufacture is obtained by removal of whey from dahi. The quality of *Shrikhand*, the final product is largely governed by the physical and chemical properties of Chakka. Aneja *et al*. (1977) reported that yield of Chakka depended on the heat treatment and TS content in skim milk. The heating of milk to 85 to 90°C for 16 sec yielded 24

and 25 percent Chakka, respectively. The Skim milk containing 11 percent TS produced highest yield.

Upadhyay and Dave (1977) reported that Chakka made from whole milk and standardized milk had smooth body but noticed higher fat loss in whey , Whereas skim milk Chakka was rough and dry. They also suggested the addition of sugar on the basis of acidity of Chakka. Sharma *et al*. (1975) analyzed both laboratory and market samples of Chakka. They reported that the laboratory made chakka contained 52 to 70 percent moisture: 8.5 percent fat, 13 to 15.6 percent protein. 0.69 to 0.78 percent ash and 2.6 percent lactose. The corresponding figures for market chakka were 59 to 81 percent. 12.41 to 20.80 percent. 10.4 to 18.4 percent, 0.68 to 0.97 percent and 0.3 to 2.1 percent. The average chemical composition of Chakka prepared from both cow and buffalo milk was reported by Mahajan (1971). The average composition for cow milk Chakka was 68.82 percent moisture and 8.92 percent fat. The respective figures for buffalo milk Chakka were 61.18 and 14.70 percent.

Patel and Chakraborty (1985) made an attempt to prepare chakka using direct acidification technology. Chakka prepared from curd using three different food grade acids, viz. lactic, hydrochloric and citric acid was considered to be unsatisfactory because of perceptible graininess. Chakka prepared with gluconodelta lactone also had graininess defect. Further, attempts to improve the curd forming properties in terms of varying heating temperature of milk. Type of skim milk, addition of sodium chloride and Iow addition of acid did not remove the grain defect completely.

Rao *et al*. (1986) studied the effect of starter cultures and drainage of whey on the quality and quantity of Chakka. They reported that out of the four different cultures tried, *S. cremoris* gave maximum yield of Chakka, followed by yoghurt culture. However chakka obtained by yoghurt culture resulted in a coarse texture with highly acidic flavoured product. Chakka obtained from curd of *S. cremoris* as a starter culture was of good organoleptic characteristics with a pleasing flavour. The acidity of curd from *S. cremoris* culture provided

optimum condition for whey separation besides confirming good body and flavour to chakka.

According to Rajorhia (2000), Chakka may be prepared from buffalo milk, because the curd obtained from cow milk is soft, weak and low curd tension. On the other hand, curd from buffalo milk is hard, smooth and mellow. Yield of *Shrikhand* from buffalo milk is about 15 to 20 percent more than that from cow.

2.1.6 Production of *Shrikhand*

Shrikhand preparation involves blending of chakka with sugar, cream and various condiments like, spices, fruits, pulp, colour, etc. The quantity of this blend depends on the final composition required in *Shrikhand*. In the traditional method, only wire mesh is used for kneading Chakka, cream and sugar to obtain desired composition and texture in the final product, Upadhyay (1981) obtained *Shrikhand* of smooth consistency by kneading chakka with 80 percent sugar and calculated quantities of pasteurized cream having 80 percent fat over a clean and sanitized wire mesh. Miyani (1982) also used wire mesh for kneading of chakka with other ingredients to obtain 6 percent fat and 40 percent sugar in the final product.

In an industrial method, Aneja *et al*. (1977) employed planetary mixer for kneading of chakka with other additives for the preparation of *Shrikhand*. Patel (1982) also employed a planetary mixer for *Shrikhand* preparation. The National Dairy Development Board, Anand has patented technology involving both the use of ultrafiltration and Scraped Surface Heat Exchange (SSHE) for the manufacture of *Shrikhand*.

2.1.7 Composition of Shrikhand

There is wide variation in the composition of *Shrikhand* is reported as reviews of various people. Upadhyay *et al*. (1975) analyzed market samples of *Shrikhand* collected from different manufactures in Gujarat and they contained 1.93 to 5.65 percent fat, 5.33 to 6.13 percent protein, 1.56 to 2.18 percent

lactose, 52.55 to 53.0 percent sucrose, 64.34 to 64.52 percent total solids and 34.48 to 35.66 percent moisture.

Sharma and Zariwala (1978) observed large variation in composition of *Shrikhand* collected from Mumbai market. The samples were reported to contain 4.5 to 11.4 percent fat, 3.4 to 5.7 percent protein, 0.66 to 2.79 percent lactose, 38.8 to 57.1 percent sucrose and 25.4 to 40.8 percent moisture. *Shrikhand* manufactured by industrial method developed by Aneja *et al*. (1977) had an average composition of 5 percent fat, 42 percent sucrose and 60 percent TS. Upadhyay and Dave (1977) reported the composition of Sugam *Shrikhand* (Baroda Dairy, Gujarat) as 40 to 43 percent moisture, 5 to 6 percent fat and 45 percent sucrose. Desai (1983) reported the composition of *Shrikhand* prepared from homogenized milk as 37.63 percent moisture, 6.31 percent fat, 7.02 percent protein and 42.68 percent sugar. The composition of *Shrikhand* as reported by Bardale *et al*. (1986) was 40 percent moisture, 6.0 percent protein and 11 percent ash. The *Shrikhand* so prepared had pleasant flavour with soft and smooth body.

According to BIS Standards (IS: 9532, 1980), *Shrikhand* should contain not less than 58 percent of total solids, 8.5 percent milk fat, 10.5 percent milk protein on dry basis and not more than 1.4 percent of titratable acidity (% LA), 72.5 percent sugar (on dry basis) and 0.9 percent of total ash. According to the microbiological quality, the product should not contain coliforms more than 10/gm and yeast and mould 50/g. The PFA Standards (1954) (amended in 2006) also hold the same standards except in case of protein. It should contain not less than 9.0 percent of protein in the finished product. No microbiological standard are prescribed under PFA.

2.1.8 Consistency of *Shrikhand*

Consistency is an important parameter for evaluating the quality of fermented milk products like yoghurt, dahi, chakka, *shrikhand*, etc. Various factors which affect the consistency of yoghurt include, milk composition, heat Treatment, homogenization, use of stabilizers, culture employed and

mechanical handling of curd (Rasic and Kurmann, 1978; Kalab, 1981). The same may hold true for *Shrikhand*.

The chemical composition of *Shrikhand* has significant influence on the consistency and sensory properties of *Shrikhand*. Miyani *et al*. (1984) assessed the effect of various levels of moisture, fat and sugar on the consistency and acceptability of *Shrikhand*. They observed an increase in the levels of moisture, sugar and fat resulted in reduction of firmness. It is reported that, *Shrikhand* containing about 6 percent fat, 35 to 40 percent moisture, and 40 percent sugar was highly preferable in terms of sensory profile and consistency of the product. Patel and Chakraborty (1985) reported that levels of moisture, fat and sugar not only influenced the consistency, but also the organoleptic qualities of *Shrikhand*. They observed an increase in penetration values and a reduction in the curd tension and coming up time the time required to pull the knife through *Shrikhand*) value of *Shrikhand* with an increase in the level of moisture, fat and sugar. They suggested that *Shrikhand* containing 6 percent fat, 41 percent sugar and 40 percent moisture had the most desirable characteristics. Patel *et al*., (1993) opined that the maximum sensory response for colour and appearance, flavour, body and texture and overall acceptability was obtained for *Shrikhand* having 8% fat and 36% sugar. Moisture binding agents commonly referred to as stabilizers are, increasingly used in the manufacture of fermented milk products such as yoghurt with a view to prevent whey separation and to have improved the consistency. Desai *et al*. (1987) studied the effect of sodium alginate and gelatin in *Shrikhand* making. They concluded that sodium alginate was unsuitable as an additive for *Shrikhand* making whereas gelatin gave equal performance as control without giving additional advantage. Homogenization of milk has been known to improve the quality of fermented products like yoghurt (Rasic and Kurmann, 1978). High fat loss in whey associated with use of whole milk for *Shrikhand* manufacturing can be avoided by homogenization of milk. Desai *et al*. (1985) reported that the fresh samples of *Shrikhand* prepared from homogenized milk had significantly higher flavour, body and texture, and total sensory score. The superiority in of *Shrikhand* samples prepared from homogenized milk was due to their smoother

body and texture, and improved flavour. They suggested the use of homogenized milk for improving the organoleptic quality and yield of *Shrikhand*.

Sodini *et al*. (2002) showed that starter culture played a very significant role in influencing rheological parameters, with the higher value obtained with the single starter culture, i.e., *S. thermophilus*. Higher graininess of fermented milk was observed with single starter culture than mixed culture, due to long fermentation time. Dairy ingredients added to increase the dry matter content, improved the rheological attributes except casein hydrolysate.

2.2 OTHER RELATED PRODUCTS

The shelf life of *Shrikhand* is extended by the preparation of products namely *Shrikhand* wadi and *Shrikhand* golla, a product resembling Gulabjamun. *Shrikhand* wadi can be compared to desiccated *Shrikhand*. In the manufacture, Chakka is first kneaded with equal quantity of crystal sugar to form *Shrikhand*. It is then desiccated in an open pan with constant stirring. This hardened mass is then mixed with 25 percent of sugar with respect to the initial weight of chakka along with additives like saffron, cardamom, etc. Mass is spread into a mat and cut into desired shape and size (Mahajan, 1971; Upadhyay and Dave, 1977).

During *Shrikhand* golla preparation, the desiccated chakka is mixed with corn flour and baking soda, followed by working the mass to small balls. These are fried in ghee, then transferred to sugar syrup containing condiments, spices and coloring matter for soaking until being served (Punjrath, 1991).

Quarg, a dairy product of European origin can be considered as the western counterpart of chakka. It is a cultured dairy product obtained by fermenting milk to a pH 4.3 to 4.8 with mixed mild cheese cultures, usually comprising *L. cremoris* and *L. lactis*, and sometime *Leuc. citrovorum* and *L. lactis subsp. diacetylactis*. It is followed by removal of whey and concentration of solids to obtain a stiff white to off-white, spreadable paste that should be

homogeneous short textured and free from serum or graininess. The product should have a clean lactic flavour and mildly acidic taste. The major markets for quarg are Germany, France, UK and Australia (Kroger, 1979; Zall, 1981; Nakazawa *et al*., 1992).

2.3 ARTIFICIAL SWEETENERS:

Sweetness is one of the most important taste sensations in humans. It has been observed that most of the food habits today involve the sweet taste in some other form. Several food ingredients stimulate the sensation of sweetness by interacting with taste receptor cells in mouth. Sucrose has been the main source of sweetness in prepared foods arid in the food industry. Food industry is constantly on the look out for alternate sweeteners. The reason for this search is two fold namely, increased calorie consciousness of the consumer who wants to lower his calorie intake, and increasing number of consumers who are diabetic. Therefore, a sucrose substitute should provide low calorie and should have insulin independent metabolism. According to Calorie Control Council (2004), an ideal sweetener should have the same sweetness as sucrose. In addition it should be odorless, colorless, stable and readily soluble in food system. It should be functional, economically feasible, noncarcinogenic and non toxic.

During past few decades, low calorie artificial sweeteners, such as aspartame, Saccharin, acesulfame and sucralose have become an alternative to sucrose and have been widely used in food formulations. Reports have shown that alternate sweeteners are superior to sucrose in some products (e.g. chewing gums) and inferior in products where texture plays a major role. Perceived sweetness depends upon number of factors: the concentration of the sweetener, temperature, pH, the ingredient in food and the sensitivity of the taster. Considering the use of high level of sucrose in *Shrikhand*, and its contribution to the calorific value of the product, the use of aspartame, saccharine and sucralose were studied in the present project and the works

related to these sweeteners are reviewed and presented in the following paragraphs.

2.3.1 Aspartame

Aspartame is a high intensity, artificial sweetener which, is being marketed under various brand names like Equal, NutraSweet, Spoonful, Indulge, Equal Measure etc. It is also added to about 1200 food products including children's vitamins, chewing gum and diet-colas. Aspartame is the most widely used artificial sweetener and has captured 50% of the world market since its introduction in 1981. It is categorized as a nutritive sweetener by FDA because it contributes the same number of calories per gram as protein. However, aspartame is used in very small quantities because it is approximately 200 times sweeter than sucrose. It is available in 90 countries over the world in more than 5000 products. In India it is being used as table top sweetener, the users being limited to a part of the diabetic population mostly in urban areas. Aspartame has exceptional sensory, nutritional and safety characteristics and can provide food, beverage pharmaceutical and manufacturing benefits (Gawande Hamant , 2003).

2.3.1.1 Structure

Aspartame is a dipeptide methyl ester of L-aspartyl-L-phenylalanine. The constituent amino acids of aspartame are phenylalanine and aspartic acid both of which are found in food. Aspartame is therefore digested in the same manner as other amino acids and peptides.

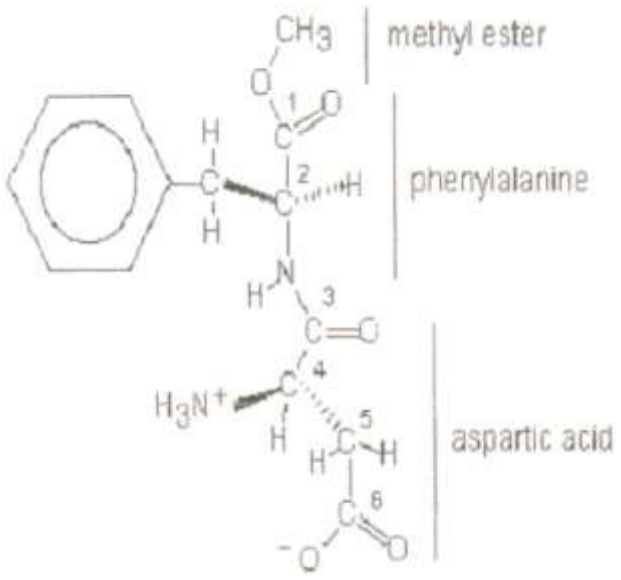


Fig.1.Structure of aspartame

(Source: Gawande Hamant , 2003).

2.3.1.2 Physico-chemical Properties of Aspartame

2.3.1.2.1 Physical properties: Aspartame is a white, odorless, crystalline powder with molecular weight 294.3 Daltons. Its main impurity (approximately 2%) is diketopiperazine, a degradation product of aspartame which has no sweetening properties, Aspartame is about 200 times sweeter than sucrose. In chocolate milk and chocolate ice cream, for example, levels of 300 and 280 mg/l, respectively are sufficient to replace 60 and 57 gm sucrose (Wieder 1989). The solubility of aspartame depends on pH and temperature. The solubility at pH 2.2 is 20 mg/ml at 25°C and the minimum stability at pH 5.2 is 13 mg/ml at 25°C www.greenfacts.org, 2005).

2.3.1.2.2: Stability

The stability of aspartame is dependent on time, pH, water activity, and buffer type and buffer concentration as well as on temperature (Prudel *et al*., 1986; Stamp, 1990). Aspartame is very stable in dry state and at 105°C, a loss of approximately 5% is observed after 100 hours of treatment. Aspartame

can withstand the heat processing and other processes in which high temperature short time and ultrahigh temperature conditions are used. In solution, when stored at temperatures ranging from 30 to 80°C, aspartame is progressively degrade into diketopiperazine (Pattanaargson *et al*., 2001). At room temperature, stability is good at pH values between 3.4 and 5 but, it is maximum at pH 4.3. pH below 3.4 the dipeptide is hydrolyzed and at a pH greater than 5, cyclisation occurs with the formation of diketopiperazine. In both cases, this transformation results in the loss of sweetness. In foods with low or moderate water content (water activities between 0.34 and 0.66), the maximum stability is observed at pH 5.0. Bell and Labuza (1991) studied kinetics of aspartame degradation in low intermediate moisture systems and were evaluated by incorporating aspartame into agar/microcrystalline cellulose model systems. Study was carried for different pH levels of 3.0, 5.0, and 7.0, water activities of 0.34, 0.56, 0.66 and storage of 25 to 45°C. Aspartame in such systems was more stable at pH 5.0 and became less stable as pH decreased or increased. As the molar buffer salt concentration increased the rate of aspartame degradation decreased. Prudel *et.al.* (1986) studied the aspartame hydrochloride decomposition relation to the pH and temperature. Aspartylphenylalanine and diketopiperazine were found to be the main decomposition product. The concentration of diketopiperazine increases and that of aspartylphenylalanine decreases with increasing pH. At pH 2.9 less aspartyl phenylalanine and more diketopiperazine is formed with increase in temperature. In products with a pH in the range 3-5, heat treatment of short duration has little effect on aspartame, but in flavoured milk with a pH of 6.3 about 25% is lost during UHT treatment for 30 sec at 140°C (Wieder, 1989). Bell and Labuza (1994) studied the aspartame stability in commercially sterilized flavoured dairy beverages that contained different buffer salts at different concentrations. Aspartame has excellent stability in fruit preparation during the manufacture of sundae-style yoghurt (Fellows *et. al*, 1991). The rate of aspartame degradation in chocolate milk was found to be related to initial microbial load and subsequent growth of contaminants (Keller *et al*. 1991). Saldamli *et. al*., (1991) observed that sensory properties of yoghurt sweetened

with aspartame and sweetened with sucrose showed equal quality characteristics. Aspartame in yoghurt was stable over a period of two weeks. Aspartame can be used in fruited or flavoured yoghurt manufacturing without showing any technological problem. It showed a slight decomposition at 42-45°C in the preparation of set yoghurt (Johnson, 1987). Keller *et.al.* (1991) evaluated three commercial yoghurt cultures and strains of *L. bulgaricus* and *S. thermophilus*, for their effect on aspartame degradation during and after fermentation. The rate of aspartame loss was related to growth of organism. Aspartame degradation rates were correlated to metabolic rate of culture, as the rate decreased. Results indicated that aspartame remained stable in yoghurt, provided it was added after fermentation.

Aspartame has good stability in deep frozen products. Major disadvantages of aspartame are its instability in acidic conditions and its loss of sweetness during prolonged heating has been addressed by coating aspartame with a partially hydrogenated vegetable oil, so that aspartame is released in the final stages during baking (Tsau and Young, 1987).Dairy proteins can influence the rate of loss of aspartame in the dairy bas beverages giving both protection and catalysis but the interaction is dependent on pH, buffer concentration and temperature (Tsoubeli and Labuza, 1992).

Malik *et. al.* (2002) evaluated the stability in carbonated beverage of three intense sweeteners including aspartame. Each sweetener was incorporated singly in the beverage in optimized concentrations of sweeteners on sucrose equivalence basis in controlled pH conditions. The loss of aspartame was greatest (29%) at the end of the 60 days storage at 37°C.

2.3.1.3: Product Application:

Aspartame is one of the most thoroughly studied food additives. It has been the subject of original research reports and reviews. The physiology, biochemist and clinical evaluation of aspartame are the subject of entire books. Following are the applications for aspartame in dairy based foods.

Goff and Pearson (1983) found aspartame to be a successful sweetener ice cream when bulked with corn syrup solids. Usage levels of 0.06-0.15%, combination with 15% low conversion corn syrup solids were recommended. Rothwell (1985) developed a formulation for diabetic and dietetic ice cream and one which used polydextrose include 4% fat, 15% polydextrose, 0.5% microcrystalline, 0.2% sodium citrate, 11.3% SNF, 0.75% stabilizers at 12ml/100 gm. Aspartame addition turned out to decrease the carbohydrate content compared with traditional marmalade with a reduction of 56% in caloric value. Assays of storage stability were resulted in non-perceptible sensorial, microbiological and chemical changes after 90 days of storage under controlled conditions. Ramakrishna *et.al.* (2004) studied rheological properties of syrup prepared by using bulk sweeteners such as sorbitol and bulking agents like maltodextrin and polydextrose along with aspartame. The yield stress, flow behavior index and consistency index were dependent on the temperature and concentration of the syrups. The apparent viscosity increased from 8.8 to12.9 mPa.s for sugar and sorbitol syrups, respectively, over the concentration range from 35 to 65%. In general, the rheological characteristic of sorbitol syrup was similar to that of sugar syrup, while syrups made with polydextrose and its mixture with maltodextrin were significantly different from those of sugar syrup. Barabolak *et.al*. (2006) patented a method for producing edible thin films involving a food grade acid and aspartame.

2.3.1.3.1 Dairy Products

Goff and Pearson (1983) found aspartame to be a successful sweetener for ice cream when bulked with corn syrup solids. Usage levels of 0.06-0.15% in combination with 15% low conversion corn syrup solids were recommended. Rothwell (1985) developed a formulation for diabetic and dietetic ice cream and one which used polydextrose include 4% fat, 15% polydextrose. 0.5% microcrystalline, 0.2% sodium citrate, 11.3% SNF, 0.75% stabilizers and emulsifiers and 0.075% aspartame. Acceptance of this ice

cream was found good. Greig *et. al.* (1985) produced no-fat no-residual lactose artificially sweetened yoghurt with aspartame, which found to have excellent viscosity, sharp milling flavour and significantly reduced energy value. Aspartame containing samples revealed slightly sweet, lingering aftertaste and sweetness was 'slow to develop' in comparison to the sucrose sweetened product. Jenesen *et al*. (1989) suggested the manufacture of ice cream containing 100 gm whipped cream, 1 egg and 1 gm vanilla, 15 gm glucose oligomer or mixture of glucose polymers as bulking agents and 0.0833 gm aspartame. This level was sufficient to replace 15 gm of sucrose in the product. Weider (1989) found that 280 mg of aspartame per liter of chocolate ice cream and 300 mg of aspartame per liter of chocolate milk is sufficient to replace 57and 60 m sugar respectively. Olsen (1989) produced Ice cream products with reduced calorie content using aspartame. Ice cream with low fat and low sugar content had composition fat 3.0 and 3.0%, sugar 12.0 and 0.0%, glucose syrup 4.0 and 0.0%, bulking agent 0.0 and 13.0%, maltodextrin 2.0 and 0.0%, aspartame 0.05 and 0.0%, stabilizer/emulsifier 0.7 and 0.7%, TS 33.2 and 30.5%, and energy content 149 and 100 kcal/100 gm. The bulking agent could be polydextrose, lactitol or palatinit, which have energy contents of 1.2 and 2 kcal/gm, respectively. Beukema and Jelen (1990) reported different high intensity sweeteners in formulation of whey beverages including formulations with 6.5% fruit juice concentration, 0.3% citric acid, 0.25% aspartame and 93% whey. Investigations indicated that aspartame can be suitable sweetening agent in cottage cheese whey based fruit drinks. Enzymic lactose hydrolysis further increased the sweetness of the aspartame sweetened product, thereby reducing the amount of high-petency sweetener required by 25-50%. Heat treatment of 30 min at 90°C resulted in no noticeable decrease in the sweetness or other changes in taste quality attributed to aspartame. Keller *et. al*. (1991 b) developed a frozen dairy dessert with complete replacement of sugar with a high potency sweetener (aspartame) without the need to add bulking agents using lactase. It consists of non fat milk solids (NFMS) 12%, 24%, 0.5% 2-fold vanilla extract, 2.0% cocoa powder, 0.08-0.1 % aspartame, 0.3 -1.0% microcrystalline cellulose, and 0.25% stabilizer. Results of sensory

analysis showed the lactase treated aspartame-sweetened frozen dessert formulation was an acceptable product, with greater acceptability than standard aspartame formulation using bulking agents, and had typical flavor profile Farooq & Haque (1992) developed low fat ice cream in which sugar was replaced with aspartame and corn syrup and overrun was kept to 80%. Guner (2002) determined the effect of using artificial sweeteners instead of sucrose only some quality characteristics of ice cream. For this purpose, aspartame and: aspartame-acesulfame-K were used to give equivalent sweetness to sucrose Reducing sucrose caused decrease in ice cream mix density, overrun and total dry solids and affected the sensory properties negatively. Aspartame had a morel positive effect on taste compared to ice creams with a blend of aspartame-acesulfame Jayaprakasha (2003) developed rasogolla with artificial sweeteners with the use of 41.77% sorbitol and 0.08% aspartame. Product had desirable shape, softness and porosity. Aspartame did not affect the sensory quality of the product except its sweetness.

Verma (2003) studied the effect of artificial sweeteners and bulking agent on physicochemical qualities of low fat frozen dessert during its preparation an storage. Among various sweeteners, aspartame produced most acceptable product. Aspartame at the rate of 400 ppm gave the sweetness equivalent to sucrose in the frozen dessert. Pandit (2004) formulated kulfi with artificial sweeteners using 4.26% maltodextrin, 5.51% sorbitol and 741.9 ppm aspartame. The level of aspartame majority affected sweetness of the product. The product was found to be sensory acceptable.

2.3.2 Saccharine:

Saccharin was commonly used as a non nutritive sweetening agent prior to its use as non nutritive sweetener. It was used as food preservative to inhibit fermentation besides its use as table top sweetener. It is now used in soft drinks, processed foods like jam, juice, chewing gum, jellies, cosmetics like toothpaste, mouthwash, lipstick, pharmaceutical coatings of tablets in tobacco products and more recently in pan masala. It is used in nickel electroplating

anti-static agent in plastic textile and in nylon dyes. It is also used in carbonated water in levels not exceeding 100 ppm (Kumar Narendra, 2006).

2.3.2.1 Physico-Chemcial Properties:

Table .1. Properties of Saccharin

Chemical nature/structure	Derivative of isothiazole
Sweetness Characteristics	Slow onset, persistent after taste
Melting point (°C)	228.8 - 229.7 (acid Saccharin), >300(Na saccharin)
pH for maximum stability	Good at pH >=3, some loss at lower pH
Solubility	Slightly soluble in water, sparingly in alcohol (2gm/L-acid saccharin, 100gm/L-Na saccharin)
Stability	Stable to heat, acid and alkali

Nabors (2001)

Table .3. Regulatory standards for saccharin

Food	**Maximum limit of saccharin in ppm**	**Regulatory body**
Sweets (carbohydrate based and milk based products):-Peda, gulabjamun, rasogolla, khoa burfi, jalebi, Halwa, boondi ladoo, mysore pak	500	PFA, 2006

Kumar Narendra (2006)

2.3.2.2 Application in Food and Dairy Products:

Saccharin has been used as a sweetener either alone or in combination with other sweeteners such as aspartame, cyclamate etc. in various food products such as sweet flavored soft, flexible, sugarless chewing gum (Carroll *et al.,* 1988), reduced calorie chewing gum (Kehoe *et al.,* 1982), spoonable frozen food product (Fisher *et al.,* 1993), bread and biscuit (Rao and Indrani, 1989), plain and fruits flavoured yoghurt (Keating and White, 1990), dry dessert mix (Lop *et al.,* 1999) low calorie jam (Gajar and Badrie, 2001), fresh packed pickles (Schafer, 2000), reduced sugar fruit spreads (Schafer, 2000), low sugar alternative for jams and jellies (Driessen, 2005), beverage (Sharkasi *et al.,* 1992), and low calorie fruit spreads (Antenucci *et al*., 1995).

A high quality, low calorie yoghurt product was prepared which consisted of 1% fat from raw cream, 11% non fat dry milk (NDM) from reconstituted NDM, 0.35% 250 bloom gelatins, 0.20% modified food starch, polydextrose and 0.013% saccharin (Keating and White 1990). The body and texture scores and apparent viscosity were not significantly different from those of the control (sucrose sweetened). However, these properties increased on prolonged storage. A substantial reduction in calories in flavored yoghurt products was achieved by employing saccharin. Calorific equivalent content of an 8-oz serving of the plain, strawberry and cherry yoghurt were 128, 121 and 126 with saccharin as compared to 154, 224 and 224 in the sucrose control respectively. Gautreb *et al.* (1979) reported that of the total sweetener replaced, when a yoghurt mix was sweetened with. 99.9% sorbitol and 0.1 % saccharin, growth of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* were retarded such that no acid was produced.

Table .2. Comparative Properties of Saccharin Forms

PROPERTIES	Acid saccharin	Sodium saccharin	Calcium saccharin
Molecular formula	C7H5NO3S	C7H4N03SNa.2H20	[C7H4NO3S]2Ca.2H20
Molecular weight	183.18	241.20	440.48
C.A.S. Registry No.	81-07-128	128-44-9	6485-34-3
Melting point (°C)	228-229	>300	>300
Appearance	White solid	White solid	White solid
Pka	1.30	-	-
Solubility (g/100g water) at:			
20 °C	0.2	100	37
35 °C	0.4	143	82
50 °C	0.7	187	127
75 °C	1.3	254	202
90 °C	-	297	247

Nabors (2001)

2.3.3 Sucralose

Sucralose is made by a patented, multi-step process that starts sugar and replaces three hydrogen-oxygen groups on the sugar molecule with three chlorine atoms.

2.3.3.1 Properties of sucralose

It is a white crystalline nonhygroscopic solid that is freely soluble in water, Sucralose molecule is made up of covalent bonds. The bonding is so strong that it does not breakdown until high temperature treatment is given

and it is extremely stable. Sucralose when dried contains 98.0 - 102.0% of sucralose. The physical and chemical properties of sucralose are depicted in Table .4.

Table.4. The physical and chemical properties of sucralose

PROPERTY	**SUCRALOSE**
Chemical	Chlorinated disaccharide
Molecular weight	397.64
Density (g/l)	283g/l
Caloric value (kg/g)	0
Relative Sweetness (w.r.t. sucrose)	600-800
After taste	No
Solubility	Freely soluble in water, methanol And alcohol, slightly soluble in ethyl acetate
Odor	Odorless
Taste	Sweet
Clarity	1.0g in 10 ml water
Specific rotation [α] 20 D	+84.0 to 87.50
P^H for max. stability	5.0-6.0
Melting point (^{o} C)	125

(NICNAS,2001)

2.3.3.2 National and International regulatory groups

Table .5. depicts the maximum limit of artificial sweetener sucralose (ppm) as approved by different national and international regulatory bodies. According to a notification amendment of the Prevention of Food Adulteration (PFA) rules, 1955 and issued by the Ministry of Health and Family Welfare in 2006, the use of four artificial sweeteners, i.e. aspartame, acesulfame-K, saccharin and sucralose in combination, within prescribed limits has been allowed in food items. The use of sweeteners has been allowed for the first time in milk based sweets like halwa, khoa, burfi, rasogolla,

gulabjamun and other milk products. The intense sweeteners approved for use in European Community (EC) are aspartame, acesulfame-K, saccharin and its sodium, potassium and calcium salts, sucralose, cyclamic acid and its sodium and calcium salts, thaumatin, and neohesperidin dihydrochalcone. The United States Food and Drug Administration (USFDA) has approved four intense sweeteners and regulates them as food additives: saccharin, aspartame, acesulfame-K and sucralose (Vijaypratap Singh 2006) **.**

Table .5. Regulatory standards for permitted artificial sweetener sucralose

Food product	Maximum limit of sucralose (ppm)	Regulatory body
Sweets (carbohydrates based and milk products based): -	750	PFA, 2006
Dairy-based drinks, flavoured and/or fermented (e.g., chocolate milk, cocoa,	300	CODEX, 2001
Dairy-based desserts (e.g., ice cream, ice milk, pudding, fruit or flavoured yoghurt)	250	CODEX, 2001

Vijaypratap Singh (2006)

2.3.3.3 Applications

Sucralose used in food in many countries because of excellent physicochemical characteristics and remarkable stability of sucralose. Sucralose was granted approval by U.S. Food and drug Administration (FDA) on April1, 1998 and approved for use in food and beverage categories .This is the brodest initial approval ever granted by FDA for a food ingredient. The FDA expanded the use for sucralose in 1999, approving it as a "general purpose" sweetener (Vijaypratap Singh 2006).

1. Flavoured milk (Jenner, 1989)
2. Bakery products (Hood and Cambell, 1990)
3. Hard confectionary (Cherukuri et al., 1992)
4. Chewing gum (Lee, 1997)
5. Baked goods & baking mixes (Chapello, 1998)
6. Soft drink (Borrego, 2000)
7. Peach compote (Mendonca, 2001)
8. Chritophene Jam (Gajar and Badrie, 2002)
9. Sherbets (Walker, 2002)
10. Milk products (Zobkova and Kutilina, 2002)
11. Dairy Foods (Berry, 2003)
12. Milky desserts (Pinto *et. al*., 2003)
13. Bread making products (Rodrigues *et. al.,* 2003)
14. Coffee and tea (Saelzer, 2004)
15. Fruit Preserves (Saelzer, 2005)

The available literature on use of artificial sweeteners indicates that, no work has been carried out so far on use of artificial sweeteners in production of Shrikhand. Hence this project was taken up to explore the possibility of using the sweeteners in production of Shrikhand and study their effect of sensory quality.

3.0 SCOPE & PLAN OF WORK

3.1 Scope

Shrikhand is one of the popular dahi based delicacy and forms part of a meal on festival occasions, Particularly during summer months . *Shrikhand* is the product which is popular in most parts of our country particularly in the states of Gujarat and Maharashtra. It is produced from dahi (curd) .whey is drained off from dahi to yield chakka. Sugar, flavor, colour and flavourings are thoroughly mixed into chakka to form a sort homogenous mass called *shrikhand*. With the changing lifestyle patterns and consumer awareness about the calories intake, the demand for low calorie food is increasing steadily. Recent amendment of PFA Act has permitted the use of artificial sweetness in dairy based foods. Keeping the need of the low calorie foods and recent changes in amendments in PFA rules, this project is taken up to standardize the technology for production of *Shrikhand* with artificial sweeteners. It is with this background the present investigation was initiated with the following plan of action and scope of study.

3.2 Product Standardization

To standardize the technology for the production of *Shrikhand* with respect to milk SNF, Acidity in chakka, Sugar level and different artificial sweeteners with different level of replacements of individual sweeteners with cane sugar.

3.2.1 Fat & SNF

Chakka prepared with skim milk with different levels of SNF was tried to increase the TS content in the final product.

3.2.2 Acidity

Skim milk was fermented to two different acidity levels of 1.6% LA, 2.0% LA to optimize the acidity in Chakka for *Shrikhand* production.

3.2.3 Sweeteners with replacements

Permitted artificial sweeteners were individually tried at different levels (upto the maximum permitted level) to study the level of sweetness in the *Shrikhand.* The combinations of individual sweeteners with cane sugar were also tried.

3.3 PRODUCT CHARACTERIZATION

The fresh product was characterized with respect to Microbiological, Chemical, Sensory & Rheological parameters.

3.3.1 Microbiological

Coliforms, Yeast & Moulds Count

3.3.2 Chemical

Protein, pH, Ash, Total Solids, Fat, water activity, Lactose, sucrose.

3.1.3 Sensory

Flavor, Color & Appearance, Body & Texture and Overall Acceptability using 9 point hedonic scale

3.3.4 Rheological

Consistency, Firmness & Index of Viscosity

3.3.5 Thermisation

The experimental samples were thermised at 65^0C for 15min to study its effect on sensory attributes of fresh *Shrikhand* and its effect on shelf life.

3.4 STORAGE STUDIES

Cups were planned to store at 37^0C & refrigeration and observed at regular intervals for the following changes in the product

3.4.1 Microbiological

Coliforms, Yeast & Moulds Count

3.4.2 Chemical

pH, Protein, Ash, Total Solids, Fat, Lactose, Sucrose.

3.4.3 Sensory

Flavor, Color & Appearance, Body & Texture and Overall Acceptability using 9 point hedonic scale

3.4.4 Rheological

Consistency, Firmness, Index of viscosity

3.5 STATISTICAL ANALYSIS

The Sensory scores of fresh product & product during storage were subjected to Statistical analysis described by SSPS computer package. The effect of acidity, SMP, fermentation of cream, thermization Were statistically analyzed by using T-test and the sensory scores of the samples were analysed by ANOVA.

4.0 MATERIALS AND METHODS

Several food ingredients stimulate the sensation of sweetness by interacting with taste receptor cells in mouth. Sucrose has been the main source of sweetness in prepared foods arid in the food industry. With the increased calorie consciousness among the consumer who wants to lower his calorie intake, and increasing number of consumers who are diabetic necessitates the search for alternative sweeteners to sucrose which can not only imparts required sweetness to the product and also reduces the calorie intake. In addition, it should be odorless, colorless, stable and readily soluble in food system. It should be functional, economically feasible, noncarcinogenic and non toxic. Keeping this in view this work was selected and the materials used in the production of *Shrikhand* using selected artificial sweeteners and methodologies adopted in production and analyses of the product are presented in this chapter.

4.1 MATERIALS:

4.1.1 Milk and cream: The skim milk (0.05 to 0.1% fat) and cream obtained from the experimental dairy were used in the experimental trials. The cream was standardized to 65% fat before it was used in the experimental trials.

4.1.2 Lactic cultures: *Lactobacillus bulgaricus* and *Streptococcus thermophilus* were obtained from Dairy Bacteriology section of National Dairy Research Institute, Bangalore, and the cultures were maintained in Dairy Technology by subculturing at weekly interval section in sterile skim milk broth.

4.1.3 Sugar: Good quality white crystalline cane sugar was procured from the local market for production of *Shrikhand.* The sugar was ground in a mixer before it was used in the trials.

4.1.4 Artificial sweeteners:

4.1.4.1 Aspartame. Aspartame was procured from Nutra sweet Coman Lovers Lane , Augusta , G A 30901 Made in USA

4.1.4.2 Sucralose: Sucralose was procured from Tate Lyl Marketed by chika pvt Ltd Mumbai , Lot Number : XD7E612701

4.1.4.3 Saccharine: Saccharine was procured from Loba Cheme PVT.Ltd , Mumbai

4.1.5 Basket centrifuge: The basket centrifuge supplied by Salvos Sales and Services ,Sadashivanagar , Bangalore – 560080 was used to drain the whey mechanically. The centrifuge was operated at 1000RPM speed.

4.1.6 Texture Analyser: The Food Texture Analyser supplied by M/s Stable Micro systems, England, was made use to study the rheological properties of the product

4.1.7 Water Activity meter: The Rotronic type Water Activity meter supplied by Rotronic, Switzerland (model BT-RS1) was used to measure the water activity of *Shrikhand.*

4.1.8 pH meter: the digital pH meter of Elico model, (Hyderabad) was made use in estimating the pH of the samples

4.1.9 Microbiological media: The ready to reconstitute microbiological media supplied by HiMedia, Mumbai were used in conducting microbiological analyses of *Shrikhand* samples.

4.1.10 Chemicals: The chemicals of Qualigens brand (Mumbai) were used in chemical analyses of *Shrikhand* samples.

4.1.11 Glasswares: The Borosil and Scott Durans brand glassware were used the experimental trials.

4.1.12 Miscellaneous materials: The required muslin cloth, polystyrene cups (100 ml capacity) and other necessary things were obtained from local market as and when they were required.

4.2 METHODS:

4.2.1 Preparation of *Shrikhand*:

4.2.1.1 Preparation of curd: Skim milk (0.05 – 0.1% fat) obtained from the experimental dairy was heat treated to 90^0C for 15 minutes and cooled to around 35^0C. One percent each of the lactic cultures (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) was added to the heat treated milk and incubated at required temperature for desired period to obtain the curd.

Similarly fresh cream standardized to 65% fat was heat treated to 71^0C for 20 min was cooled to about 35^0C and the lactic cultures were added before it was separately incubated along with milk.

4.2.1.2 Drainage of whey: The obtained curd (3.2.1.1) was then transferred to muslin cloth and hanged in cold room for overnight. The curd was hanged in cold room to control the increase in acidity during drainage period. For mechanical removal of whey, the curd was fed into basket centrifuge bowl (lined with muslin cloth) and subjected to centrifugal force at around 1000 rpm speed for 10 minutes. At the end of 10 minutes of rotation, the semi solid mass of curd (Chakka) was collected from the bowl. In experimental trials to increase the total solid content in chakka, curd was hanged in muslin cloth for overnight and further, the chakka was subjected to centrifugation to remove further more whey from chakka.

4.2.1.3 Preparation of *Shrikhand*: The chakka was added with fermented cream at the rate of 25% of chakka to obtain final fat content of 9% in the final product. The ground cane sugar to cream added Chakka (3.2.1.2) at different levels and kneaded to obtain smooth, thick creamy consistancy *Shrikhand*.

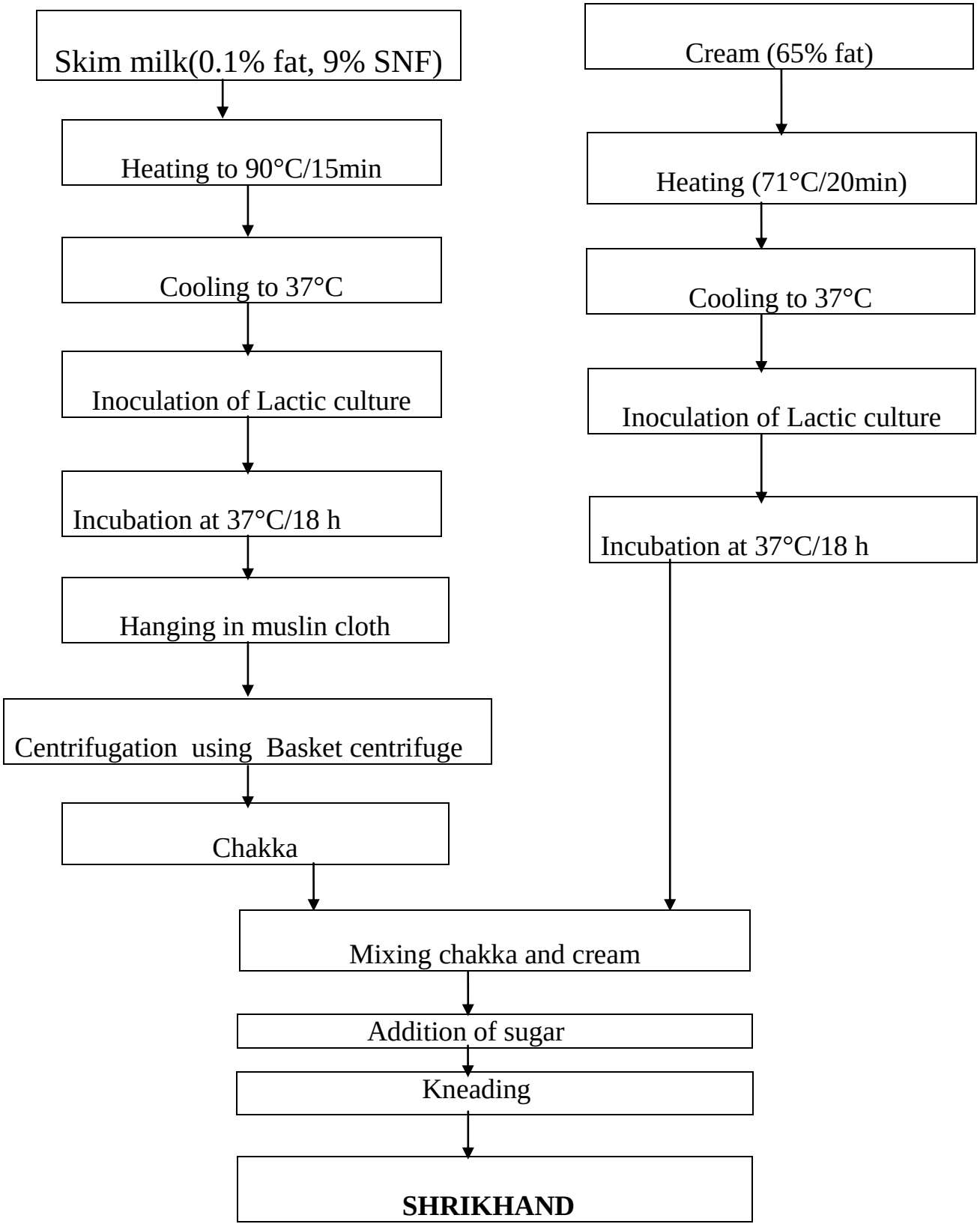


Fig.3. FLOW DIAGRAM FOR PREPRATION OF SHRIKHAND

Sugar was added at 35, 45, 55 and 65% of chakka level (w/w) to optimize the sugar level in *Shrikhand*. The detailed flow diagram is shown in Fig.3.

The selected artificial sweeteners (Aspartame, Saccharine and Sucralose) were added to cream added chakka to replace 25, 50, 75 and 100% replacement of cane sugar to study the effect of replacement of the sweeteners on the sensory quality of *Shrikhand*. The *Shrikhand* prepared with 100% cane sugar was served as control sample.

4.2.2 Chemical Analysis:

4.2.2.1 Milk: The fat content in skim milk was estimated by Gerber method and SNF was calculated by using formula

MSNF=0.25CLR + 0.25F + 0.40

CLR=corrected lactometer reading

F=fat per cent of milk

4.2.2.2 Cream: The fat content in cream was estimated by dilution method, wherein the cream was diluted by 10 times and fat content in diluted cream was estimated by Gerber method. The value obtained was multiplied by 10 to obtain the actual fat content in cream.

4.2.2.2.3: Chakka

4.2.2.2.3.1: Total solids

Total solids of Chakka were determined gravimetrically using Mojonnier test assembly as per the method of IS: SP: 18 (Part XI), 1981. A representative sample of 3g was weighed into pre-weighed TS dish with acid washed sand and glass rod and dried to a constant weight at 100±1˚C .The percentage TS was calculated as follows:

$$\text{Percent TS} = \frac{\text{Weight of dried Sample}}{\text{Sample Weight}} \times 100$$

4.2.2.2.3.2: Acidity

Acidity of Chakka was estimated by titration method as per the procedure described in (IS: 1479,I&II, 1961; IS: 9532:1980) Ten grams of the sample was diluted with equal amount of water and titrated against N/9 sodium hydroxide solution with phenolphthalein as indicator

4.2.2.4 Shrikhand

4.2.2.4.1 Fat

The fat content of *Shrikhand* was determined by Mojonnier method (IS: SP-18, Part-X1, 1981).

4.2.2.4.2 Protein: The protein content of *Shrikhand* was determined as per the ISI procedure (micro-kjeldahl method) described in IS: SP: 18 (Part XI), 1981.

4.2.2.4.3 Sucrose and Lactose

The sucrose and lactose were estimated essentially by the volumetric method of Lane-Eynon (IS: SP-18, Part-X1, 1981) prescribed for condensed milk

4.2.2.4.4 Ash:

The ash content in the *Shrikhand* samples were estimated as per the procedure explained in IS: 1547 (1968).

4.2.2.4.5 Acidity:

Acidity of *Shrikhand* was estimated by titration method as per the procedure described in (IS: 1479,I&II, 1961; IS: 9532:1980) Ten grams of the sample was diluted with equal amount of water and titrated against N/9 sodium hydroxide solution with phenolphthalein as indicator.

4.2.2.4.6 Total solids

Total solids of *Shrikhand* were estimated as per ISI procedure (gravimetric Method) described in IS: SP: 18 (Part XI), 1981.

4.2.3 MICROBIOLOGICAL ANALYSIS:

4.2.3.1 Yeast and Mould count: The enumeration of yeasts and molds was done by using Potato Dextrose Agar medium. The composition of the medium was as follows:

Ingredients	Quantity (g/litre)
Potato infusion from	200 g
Dextrose	20 g
Agar	15 g
Distilled water	1000 ml.

The dehydrated medium was obtained from HiMedia, Mumbai. To a known quantity of dehydrated medium, required quantity of distilled water was added and boiled to dissolve the ingredients. Immediately after boiling, the medium was dispensed into erlenmeyer flasks and autoclaved at 121^0C for 15 min.

The *Shrikhand* samples were serially diluted by using sterile peptone water and an aliquot of 1 ml of appropriately diluted sample was pour plated in duplicate by using the PDA medium. Before pouring the medium the pH of the medium was adjusted to about 5.4 by addition of 2-3 drops of sterile tartaric acid solution (10% strength) into the plates. The plates were incubated at 30^0C for 3 to 5 days. The plates were observed for yeast and mold colonies and counted, multiplied by the dilution factor and expressed as cfu/g of sample.

4.2.3.2 Coliforms: The coliforms were estimated by using VRBR medium. The composition of the medium was as follows.

Ingredients		Quantity (g/liter)
Peptic digest of animal tissue	:	7.00
Yeast extract	:	3.00
Bile salts mixture	:	1.50
Lactose	:	10.00
Sodium chloride	:	5.00
Neutral red	:	0.03
Crystal violet	:	0.002
Agar	:	15.00
Final pH (at 25^{o}C)	:	7.40 $\pm$ 0.1

A known quantity of dehydrated medium was dissolved in requisite quantity of water and boiled to dissolve the ingredients. The boiled medium was dispensed into erlenmeyer flasks and autoclaved at 121^{0}C for 15 min.

Ten gram aliquot of *Shrikhand* samples were serially diluted in sterile peptone water and pour plated in duplicate by using VRBR medium. The plates were incubated at 37^{0}C for 24 – 48 hours and observed for the bacterial colonies on the surface of the medium. The count was multiplied by the dilution factor and expressed as cfu/g.

4.3 WATER ACTIVITY:

The water activity (a_w) of the product was determined using the digital water activity meter (ROTRONIC, HYGROSCOP, BT-RS1). The sample was filled in the dish provided by the company and place in the instrument. Water

activity, which is the ratio of vapour pressure of water in the powder to the vapour pressure of pure water at the same temperature was directly read on the monitor.

4.4 RHEOLOGICAL ANALYSIS:

The texture analyser was used to evaluate the firmness, consistency and viscosity index of *Shrikhand*. The following steps were undertaken to run the texture analyzer:-

Computer was linked to the texture analyses and texture exponent 32 programmed was marked.

The p/25 aluminium cylindrical probe was fixed to the machine.

Under TA setting command, library option was opened.

Under library, “return to start” was selected which meant the probe would return to original position after penetrating the sample to the required distance. The following project settings were loaded:-

Test mode	:	Compression
Pre-test-speed	:	1.00 mm/sec
Test-speed	:	2.00 mm/sec
Post-test speed	:	10.00 mm/sec
Target mode	:	Distance
Distance	:	10.00 mm
Trigger type	:	Auto (Force)
Trigger force	:	2.0 g
Tare mode	:	Auto
Advanced options	:	On
Break mode	:	Off

The probe height was calibrated to 50mm.

Yoghurt (8+20C) in 100ml plastic cup was kept on the platform and probe was positioned centrally and close over the sample surface.

When test was run, the probe travelled to a distance of 10mm into the product after 2g of force was sensed by the probe and returned to original position, generating a force-time curve as shown in Fig. 2.

The maximum force on positive peak of the curve was noted and expressed as firmness (i.e. the force required to penetrate the probe to the specified distance in to the sample) in terms of grams.

Consistency (i.e. work done during the travel of the probe) was determined by calculating the area under the positive peak of the curve in terms of grams seconds.

Area under negative peak was taken as viscosity index (i.e. pulling force exerted by the sample during withdrawal of the probe from the product) and expressed as grams seconds.

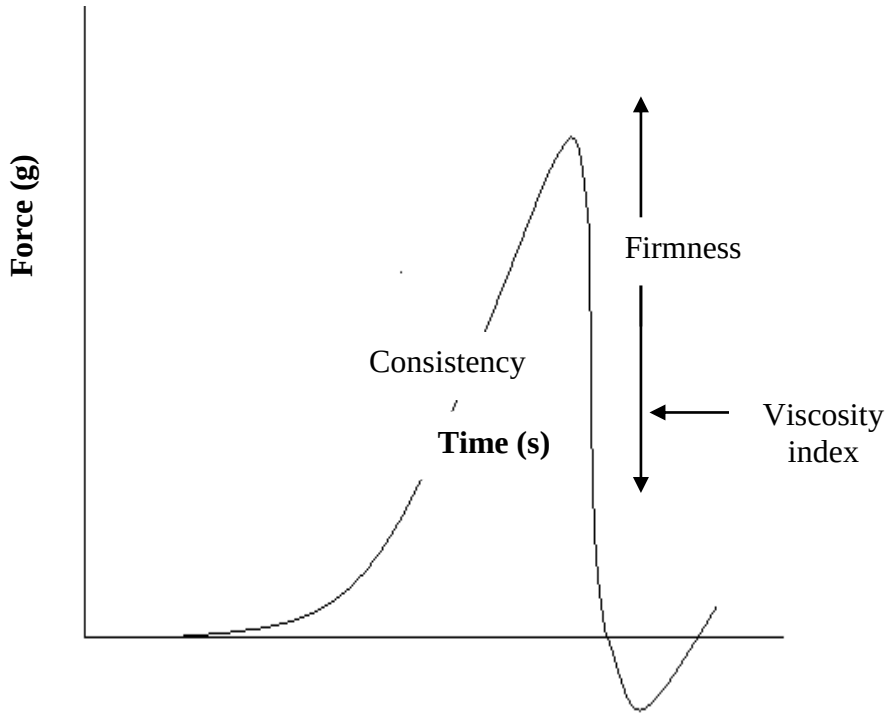


Figure. 2. Force-time curve

4.5 THERMIZATION: The *Shrikhand* samples prepared by using cane sugar (control) and experimental samples (using artificial sweeteners) were subjected to a heat treatment of 65^0C for 15 min and immediately hot packed in polyethylene cups and closed. The polyethylene cups were sanitized by dipping the polyethylene cups in 300ppm chlorinated water for 30 min and dried.

4.6 SENSORY EVALUATION: The *Shrikhand* samples were analyzed for sensory parameters like Colour & Appearance, Sweetness, Flavour, Body & Texture, and overall Acceptability. The samples were served to a panel of 6 trained judges to evaluate the product on 9 point hedonic scale, wherein the score of 9 indicates extremely liked and score of 1 indicated extremely disliked. The format of the score card in enclosed in appendix 1.

4.7 STORAGE STUDIES:

The thermized *Shrikhand* samples were at two different temperatures of 37^{o}C and refrigeration temperature (6-8^{o}C) to study the shelf life .one set of samples containing control and experimental samples stored at 37^{o}C was drawn at 24hrs intervals for sensory and microbiological studies. The samples stored at 4^{o}C were drawn at 7 days intervals to sensory and microbiological parameters.

5.0 RESULTS AND DISCUSSIONS

Shrikhand is most popular dahi based product or contain nearly 40-50 % sugar. With increased awareness among consumers, the demand for low sugar products is increasing steadily. Recent amendments in PFA rules, has opened a wide scope to use artificial sweeteners in milk based foods. Keeping this in view, the present work was taken up and the results are presented in the following paragraphs and discussed.

5.1 Optimization of SNF in skim milk for *Shrikhand* production.

Shrikhand was prepared from skim milk with two different SNF levels of 9.0 and 10.5 %. The SNF of skim milk was increased by addition of SMP. The product was evaluated for yield, acidity and sensory parameters and results are presented in the Table.6. The results indicated that the yield of chakka increased with increase in SNF content in skim milk Aneja et al(1977) reported 2% increase in chakka yield when SNF level in skim milk was increased from 10% to 11%. No much difference was observed in acidity development in milk which was indicated by almost same level of acidity (around 1.64% LA) in chakka. The *Shrikhand* prepared by using skim milk with 9.0% SNF had smooth homogenous body with clean dahi flavour, while that made from skim milk with 10.5% SNF had slight grainy body and powdery flavour. Aneja et al (1977) also reported powdery flavour in the finished product prepared by using skim milk containing 11% SNF. Statistical studies of sensory scores showed the significance difference between the two treatments.

Table.6. Effect of addition of SMP to milk on sensory quality of chakka.

	9.0	10.5	
Yield	29.5	30.8	t-test
Acidity	1.61	1.64	
Body & Texture	7.3	7.1	5.0*
Flavour	7.5	7.1	4.9*

Average of 3 observations

* : significant at 5% level NS: Not Significant at 5 % level

5.2 Optimization of acidity level in chakka.

Shrikhand was prepared from chakka having two different acidity levels of 1.6 and 2.0% .The product was evaluated for sensory parameters and results are presented in Table 7 and Fig 4. The Table indicates that the change in acidity level did not show any significant effect on the colour and appearance of *Shrikhand*. Where as the flavour and sweetness was significantly affected. The higher sourness in chakka with 2.0 %LA acidity reduced the sweetness effect and thus has reduced the flavour score. Though the body texture score was not significantly different between the two treatments, the overall acceptability score showed significant variation which could be mainly due to flavour and sweetness scores. The Streptococcus and Lactobacillus bulgaricus cultures (mixed in 1:1 ratio) were used in the present study. Baisya and Bose (1974) and Garg and Jain (1980) also advocated he use of the cultures in 1:1 ratio.

Table .7.Effect of acidity of chakka on sensory quality of *Shrikhand*

Sensory attributes	Treatment1	Treatment2	t-Value
Colour and appearance	7.7	7.4	1.8 ^{NS}
Sweetness	7.7	6.2	5.0*
Flavour	7.8	6.3	5.2*
Body and texture	7.7	7.2	5.0*
Over all acceptability	7.6	6.9	7.5*

Average of 3 observations

Treatment1:-preparation of *Shrikhand* with chakka having acidity of 1.6

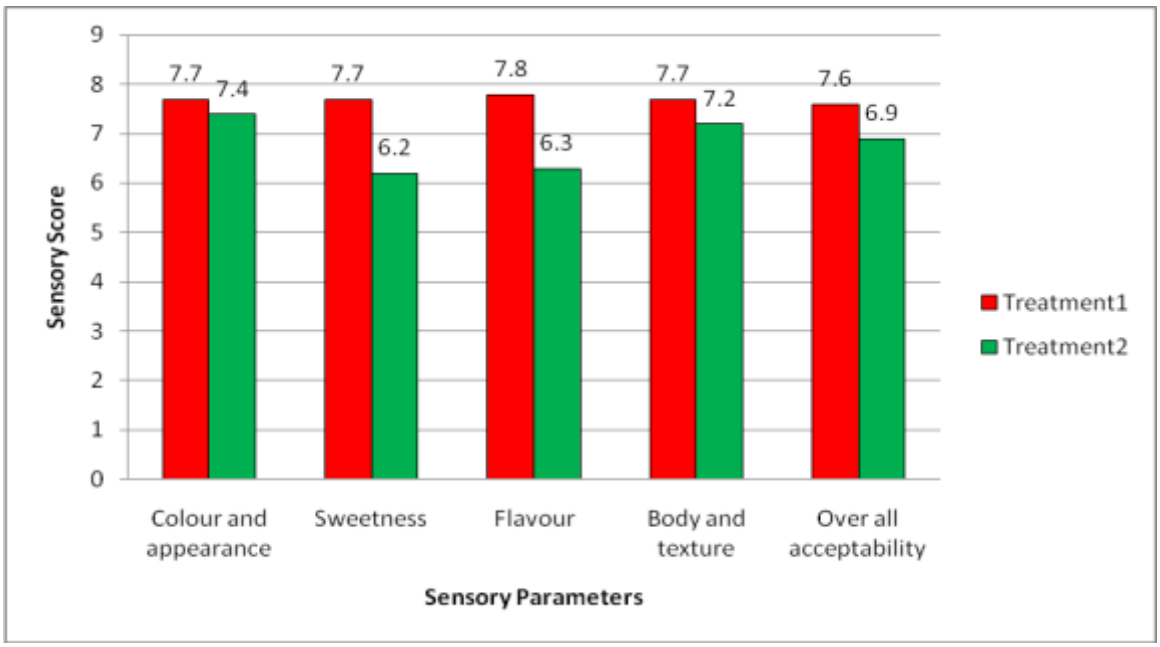
Treatment2:-preparation of *Shrikhand* with chakka having acidity of 2.0

*: significant at 5% level NS: Not Significant at 5 % level

Incubation temperature= 37^{o}C

Incubation Period = 16 hr

Fig.4. Effect of acidity levels in chakka on sensory attributes of *Shrikhand*



Treatment1-acidity of chakka is1.6%LA,

Treatment2-acidity of chakka is 2.0%LA

5.3 Optimization of Sugar level.

The results shown in Table .8. and Fig.5 indicate the sensory score of *Shrikhand* prepared by using different levels of sugar. The variation in sugar level has very less effect on the colour and appearance scores of the product. The sweetness and flavour scores increased as the percentage of sugar in *Shrikhand* increased. The difference in the scores between 35% and 45% was not significant while addition of 55% and above sugar significantly improved the sweetness and flavour. Aneja et al (1977) reported the use of about 80% sugar by weight of chakka, when the acidity of chakka was in range of 2.2 to 2.5, to obtain satisfactory quality *Shrikhand*. The body and texture scores also showed improvement in body and texture of *Shrikhand* with increased levels of sugar. The texture becomes smoother with increased sugar content in the product. The statistical analysis of the results shows significance in treatment for sweetness, flavour and overall acceptability while the treatments have no significant effect on body and texture and appearance.

Table.8.Sensory scores of *Shrikhand* prepared with different levels of sugar.

Sensory parameters	Sugar level (%) of chakka				$CD^{0.05}$
	35	45	55	65	
Appearance	7.4^{a}	7.4^{a}	7.5^{ab}	7.6^{b}	0.16
Flavour	6.1^{a}	6.4^{a}	7.1^{b}	7.9^{c}	0.36
Sweetness	6.1^{a}	6.4^{a}	7.0^{b}	8.0^{c}	0.44
Body and texture	7.2^{a}	7.4^{b}	7.4^{b}	8.1^{c}	0.19
Over all acceptability	6.2^{a}	6.5^{b}	7.1^{c}	7.9^{d}	0.28

Average of 3 trials

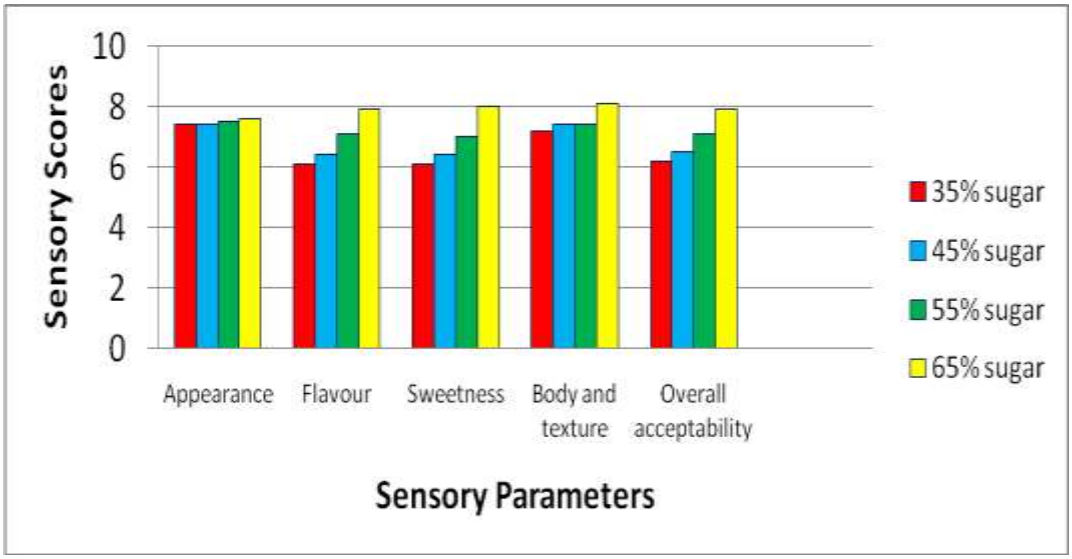
Figure with different superscripts in a row are significantly different at P≤0.05

ANOVA

Source	df	Sweetness		Flavour		Body		Appearance		Overall acceptability	
		MSS	F Value	MSS	F Value	MSS	F Value	MSS	F Value	MSS	F Value
Between Levels	3	2.10	194.5*	1.901	194*	0.47	59.0*	0.025	2.9*	1.83	388*
Judges	5	0.08	7.4*	0.052	7.4*	0.01	1.96^{NS}	0.01	1.2^{NS}	0.03	6.8*
Error	15	0.59		0.91		1.03		0.41		0.32	
Total	24										

* : significant at 5% level NS: Not Significant at 5 % level

Fig.5.Sensory scores of *Shrikhand* prepared with different levels of sugar



5.4. Effect of fermentation of cream on sensory quality of *Shrikhand.*

The results presented in Table 9 and Fig 6 shows the effect of fermentation of cream on the sensory quality of *Shrikhand.* It was found that the addition of fermented cream significantly improved all the sensory parameter of *Shrikhand.* The colour and appearance improved by addition of fermented cream due to homogenous shiny appearance. Addition of fresh cream resulted in flat taste in *Shrikhand,* due to reduced typical dahi (diacetyl) flavour in *Shrikhand* while the fermentation of cream and addition to chakka retained the optimum level of

dahi flavour resulting in the increased score. Similarly the body and texture scores improved significantly in fermented cream added *Shrikhand*. The product had smooth homogenous body with firm consistency. The firmness in *Shrikhand* was due to the good gel formed in cream during fermentation which has added to the firmness of chakka. *Shrikhand* prepared by using fresh cream has loose body which could be due to dilution of firmness due to the fresh cream.

Table.9.Effect of fermentation of cream on sensory quality of shrikhand

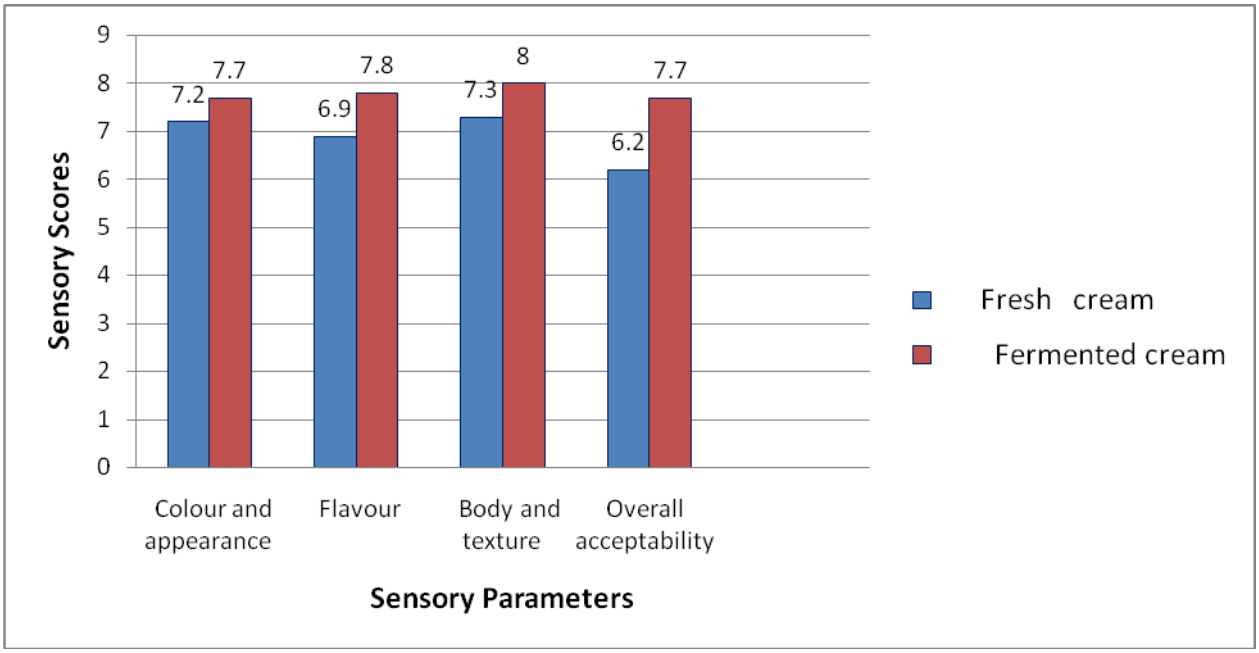
Sensory parameters	Treatment1	Treatment2	t-Values
Colour and appearance	7.2	7.7	20.5*
Flavour	6.9	7.8	7.75*
Body and texture	7.3	8.0	15.0*
Overall acceptability	6.2	7.7	14.0*

Treatment1:- *Shrikhand* prepared with fresh cream

Treatment2: *Shrikhand* prepared with fermented cream

*: significant at 5% level NS: Not Significant at 5 % level

Fig.6.Effect of fermentation of cream on sensory quality of *Shrikhand*



5.5 Optimization of sucralose equivalent to cane sugar

In order to optimize the sucralose equivalent to cane sugar, sucralose was added to *Shrikhand* at different levels and compared the sensory scores with those in *Shrikhand* prepared by using cane sugar at 65% by weight of chakka. The results are presented in Table 10. The sucralose was tried to a maximum level of 75mg/100gm of chakka (750ppm) since this is the upper limited for sucralose permitted by PFA in milk based products. The table indicates that none of the levels of sucralose in *Shrikhand* was comparable to the control in all the parameters. The sweetness was found to be almost uniformly same in the *Shrikhand* prepared by using 600, 650 and 700ppm of sucralose in the product. The sweetness improved in *Shrikhand* prepared by using 750ppm of sucralose. However the sweetness was much below the acceptable level when compared to *Shrikhand* prepared by using 65% sugar by weight of chakka. Similar trend was found in flavour scores. The sucralose added Shrikhand had sour taste with dominating lactic flavour and was lacking the sweet flavour. The body and texture scores also shows that the sucralose added samples scored almost similar varying between 6.0 and 6.3. This was mainly due to the very firm body. The main reason for firmer body was due to lack of sugar. The *Shrikhand* with cane sugar had smooth body. The study indicates that sugar had main role to play not only in flavour but also contributes to the body & texture of Shrikhand. The statistical analysis of scores indicates that the experimental samples significantly differed from control sample in all the sensory parameters.

Table.10. Optimization of sucralose equivalent to cane sugar

Sensory parameters	Per 100 gm chakka					CD $^{0.05}$
	60mg (600ppm)	65mg (650ppm)	70mg (700ppm)	75mg (750ppm)	65 gms sucrose (control)	
Sweetness	4.3^{a}	5.0^{ab}	5.0^{ab}	6.0^{bc}	7.5^{c}	1.58
Flavour	4.0^{a}	4.6^{ab}	5.3^{bc}	6.3^{c}	7.5^{d}	1.08
Body and texture	6.0^{a}	6.1^{a}	6.1^{a}	6.3^{a}	7.3^{b}	0.49

Average of 3 trials

Figure with different superscripts in a row are significantly different at P≤0.05

ANOVA

Source	df	Sweeteness		Flavour		Body	
		MSS	F Value	MSS	F Value	MSS	F Value
Between Levels	4	4.567	4.183*	5.733	11.279*	0.858	7.923*
Judges	5	5.217	4.779*	5.217	10.262*	5.400	49.846*
Error	20	1.092		0.508		0.108	
Total	30						

*: Significant at 5% level NS: Not Significant at 5% level

5.6 Optimization of Aspartame equivalent to cane sugar.

In order to understand the sweetness equivalent of aspartame to cane sugar in *Shrikhand,* Aspartame was added at different levels to *Shrikhand* and evaluated for sweetness, flavour and Body & Texture. The results are presented in Table.11. The Table clearly indicates that sweetness and flavour scores increased significantly with increased level of aspartame in the product. However, the body and texture did not show much difference among the *Shrikhand* prepared by using different levels of aspartame. But the scores

differed significantly when compared to control sample prepared by using cane sugar. This could be due to smoother body with shiny in control sample appearance. The aspartame was tried beyond 200ppm level in the study since the maximum permitted level for use of aspartame in milk based foods is 200ppm. The artificial sweetness added samples had firmer body with granular texture when compared those with control *Shrikhand.*

Table .11. Optimization of Aspartame equivalent to cane sugar

Sensory parameters	Per 100 gm chakka					CD $^{0.05}$
	50mg	100mg	150mg	200mg	65 gms sucrose(control)	
Sweeteness	3.6^{a}	4.8^{b}	5.0^{bc}	6.1^{c}	7.6^{d}	1.16
Flavour	4.1^{a}	4.8^{ab}	5.0^{b}	6.2^{c}	7.5^{d}	0.84
Body and texture	6.0^{a}	6.1^{a}	6.1^{a}	6.1^{a}	7.5^{b}	0.61

Average of 3 trials

Figure with different superscripts in a row are significantly different at P≤0.05

ANOVA

Source	df	Sweetness		Flavour		Body	
		MSS	F Value	MSS	F Value	MSS	F Value
Between Levels	4	6.64	11.225*	5.216	17.063*	1.225	7.538*
Judges	5	3.71	6.282*	4.214	13.786*	4.017	24.718*
Error	20	0.59		0.306		0.163	
Total	30						

*: Significant at 5% level NS : Not Significant at 5% level

5.7 Optimization of saccharin equivalence to cane sugar in shrikhand

The results of the sensory scores of *Shrikhand* prepared by using different levels of saccharin are presented in Table 12. As in the case of aspartame, the sweetness and flavour scores of Shrikhand increased with increase in saccharine content in the product. However the scores for *Shrikhand* even with highest level of 500ppm was significantly lower compared to control sample. This was mainly due to lower sweetness of the product indicates that even the higher permitted level of aspartame could not impart desired sweetness to the product.

The body & texture scores also indicate that the saccharine added samples had firmer body as in the case of *Shrikhand* prepared by using aspartame and sucralose .The firmer and slightly granular body resulted in lower score for experimental samples compared to control sample.

The results presented in tables 10, 11 and 12 clearly indicates that, none of the artificial sweetness tried could not impart desired sweetness and flavour to the fermented products even at higher permitted levels. combination of these individual sweetness with cane sugar is required to obtain desired sweetness and body and texture to *Shrikhand.* Hence the individual sweetness (at maximum permitted levels) along with different levels of sugar were tried to optimize sensory scores and the results are presented in following tables:

Table.12. Optimization of Saccharin equivalent to cane sugar

Sensory parameters	Per 100 gm chakka					CD $^{0.05}$
	200mg	300mg	400mg	500mg	65 gms sucrose (control)	
Sweetness	4.3^{a}	5.0^{ab}	5.0^{ab}	6.0^{b}	7.5^{c}	1.41
Flavour	4.1^{a}	4.6^{ab}	5.1^{b}	6.2^{c}	7.3^{d}	0.93
Body and texture	6.0^{a}	6.1^{a}	6.3^{a}	6.4^{a}	7.4^{b}	0.62

Average of 3 trials
Figure with different superscripts in a row are significantly different at P≤0.05

ANOVA TABLE

Source	df	Sweetness		Flavour		Body	
		MSS	F Value	MSS	F Value	MSS	F Value
Between Levels	4	4.142	4.779*	4.826	12.846*	1.076	6.435*
Judges	5	4.117	4.750*	4.101	10.916*	5.048	30.197*
Error	20	0.867		0.376		0.167	
Total	30						

*: Significant at 5% level NS : Not Significant at 5% level

5.8 Optimization of sucralose and cane sugar combination in *shrikhand*.

Attempts were made to use sucralose in combination with sugar at different levels and the results are presented in Table .13.The results indicate that the sample prepared by using 25% sugar with 750ppm of sucralose was less accepted due to sourness and harder body. on the other hand , when 750ppm sucralose in combination with 50% of sugar and 75% of sugar used in *Shrikhand* production no difference in sweetness & flavour between the two levels were observed and the sample. No significant differences were observed between control and these experimental samples. Similarly the body texture scores indicate that the sample made from 750ppm sucralose + 25% of sugar scored a score of 7.1. The score improved to 7.5 when the sugar content was increased to 50% of sugar, Further increase in scores of 50% and 75% of sugar scored well with control sample and statistical analysis shows no difference between the two treatments and control sample . The overall acceptability scores also showed similar trend of lower score for *Shrikhand* with 750ppm sucralose +25% of sugar and higher scores for other samples.

Table.13. Optimization of sucralose and cane sugar combination in *Shrikhand*

Sensory parameters	750ppm Suc+ 0%sugar	750ppm Suc + 25%sugar	750ppm Suc + 50%sugar	750ppm Suc + 75%sugar	65 gm Sugar (control)	CD $^{0.05}$
Appearance	6.0^{a}	6.7^{ab}	7.2^{b}	7.4^{b}	7.5^{b}	0.90
Sweetness	6.2^{a}	6.6^{b}	7.4^{b}	7.5^{c}	7.6^{c}	0.57
Flavour	5.8^{a}	6.8^{a}	7.4^{b}	7.4^{bc}	7.6^{c}	0.73
Body and Texture	6.8^{a}	7.1^{ab}	7.5^{ab}	7.5^{bc}	7.6^{b}	0.70
Overall acceptability	5.7^{a}	6.6^{a}	7.5^{b}	7.5^{c}	7.7^{c}	0.81

Average of 3 trials

Figure with different superscripts in a row are significantly different at P≤0.05

ANOVA TABLE

Source	df	Sweetness		Flavour		Body		Appearance		Overall acceptability	
		MSS	F Value	MSS	F Value	MSS	F Value	MSS	F value	MSS	F Value
Between Levels	4	3.193	15.4*	3.23	9.54*	2.44	5.010*	2.22	4.26*	3.495	8.321*
Judges	5	0.99	4.80*	1.81	5.35*	0.49	1.011*	2.85	5.48*	1.600	3.810*
Error	20	0.20		0.33		0.48		0.52		0.42	
Total	30										

*: Significant at 5% level NS : Not Significant at 5% level

5.9 Optimization of aspartame and cane sugar combination in *Shrikhand.*

The aspartame at maximum permitted level of 200ppm with different levels of sugar was added to *Shrikhand* to optimize the combinations and the results are presented in Table.14. The table shows that the sweetness and flavour scores for *Shrikhand* containing 200ppm aspartame and 25% of sugar were 6.0 and 6.3 respectively. The scores improved correspondingly to 6.8 and 6.5 when the sugar content was increased to 50% of sugar. The scores further improved to 7.3 and 7.6 respectively, when sugar content was increased to 75% of sugar. There scores were comparable to control sample which scored 7.7 and 7.8 respectively. Similarly the body & texture and overall acceptability scored improved with increased sugar level in *Shrikhand*. The statistical analysis indicates the significant difference between the treatments for all the sensory parameters and no significance between control, sample and *Shrikhand* containing 200ppm and 75% of sugar. Greig et al (1985) produced no-fat, no-residual lactose artificially sweetened yoghurt with aspartame, which found to have excellent viscosity.

Table.13. Optimization of aspartame and cane sugar combination in *Shrikhand*

Sensory parameters	200ppm asp+ 0%sugar	200ppm asp + 25%sugar	200ppm asp + 50%sugar	200ppm asp + 75%sugar	65 gm Sugar (control)	CD $^{0.05}$
Appearance	5.6^{a}	6.6^{b}	7.1^{bc}	7.3^{cd}	7.7^{d}	0.57
Sweetness	5.0^{a}	6.0^{b}	6.8^{c}	7.6^{d}	7.8^{d}	0.44
Flavour	6.3^{a}	6.3^{a}	6.5^{a}	7.3^{b}	7.6^{b}	0.64
Body and Texture	5.7^{a}	6.3^{b}	6.6^{b}	7.4^{c}	7.5^{c}	0.56
Overall acceptability	5.0^{a}	6.0^{b}	6.9^{c}	7.4^{d}	7.6^{d}	0.38

Average of 3 trials

Figure with different superscripts in a row are significantly different at P≤0.05

ANOVA TABLE

Source	df	Sweetness		Flavour		Body		Appearance		Overall acceptability	
		MSS	F Value	MSS	F Value	MSS	F Value	MSS	F value	MSS	F Value
Between Levels	4	5.54	44.8*	3.14	12.1*	2.28	11.1*	2.61	12.5*	4.81	51.13*
Judges	5	0.44	3.62*	1.82	7.0*	0.77	3.7*	1.54	7.3*	0.33	3.53*
Error	20	0.12		0.21		0.20		0.20		0.09	
Total	30										

*: Significant at 5% level NS: Not Significant at 5% level

5.10 Optimization of saccharine and cane sugar combination in *Shrikhand.*

Similar to the trials taken up for sucralose and aspartame, attempts were made to use sucralose (at maximum permitted level) along with different levels of sugar to optimize the combination of two sweeteners , and the results are presented in Table.15.Tthe colour and appearance was significantly different between the samples due to differential shining and smoothness . The surface was found more shiny and more homogenous as the sugar level in the sample increased. Similarly the flavour and sweetness scores improved significantly with increased sugar level. The body and texture scores also improved with the sugar level in the product *Shrikhand* become smoother and softer with increase in sugar level. Keating and White (1990) produced a high quality, low calorie yoghurt by using 0.013% saccharine.

The statistical analysis of the scores indicate that though the scores varied significantly between the samples, the scores for all the parameters of control sample and *Shrikhand* prepared by using a combination of 500ppm saccharine and 75% sugar did not vary significantly , indicating that this combination of sweeteners was found suitable to produce *Shrikhand* comparable to control *Shrikhand*.

Table.15. Optimization of saccharin and cane sugar combination in *Shrikhand*

Sensory parameters	500ppm sacc + 0%sugar	500ppm sacc + 25%sugar	500ppm sacc + 50%sugar	500ppm sacc + 75%sugar	65 gm Sugar (control)	CD $^{0.05}$
Appearance	5.6^{a}	6.5^{b}	7^{bc}	7.2^{cd}	7.7^{d}	0.55
Sweetness	5.5^{a}	6.2^{b}	6.1^{b}	7.5^{c}	7.9^{c}	0.46
Flavour	5.3^{a}	6.3^{b}	6.5^{b}	7.3^{c}	8.0^{d}	0.57
Body and texture	5.7^{a}	6.6^{b}	7.2^{c}	7.4^{c}	7.5^{c}	0.56
Overall acceptability	5.5^{a}	6.2^{ab}	7.0^{bc}	7.4^{cd}	7.9^{d}	0.81

Average of 3 trial ,Figure with different superscripts in a row are significantly different at P≤0.05

ANOVA TABLE

Source	df	Sweetness		Flavour		Body and Texture		Appearance		Overall acceptability	
		MSS	F Value	MSS	F Value	MSS	F Value	MSS	F value	MSS	F Value
Between Levels	4	3.85	28.27*	4.18	20.0*	2.36	11.7*	2.50	12.83*	3.49	8.32*
Judges	5	0.51	3.80*	1.53	7.3*	0.55	2.0 *	1.46	7.51*	1.60	3.81*
Error	20	0.13		0.20		0.20		0.19		0.42	
Total	30										

*: Significant at 5% level NS: Not Significant at 5% level

5.11. Comparison of sensory scores of *Shrikhand* prepared by using artificial sweeteners with selected combinations

The *Shrikhand* prepared by using artificial sweeteners with selected combination with sugar are compared for sensory evaluation with control and scores are presented in Table.16. The result indicates that, there was no significant difference between the sweeteners and control samples in all the sensory parameters. The scores varied very narrowly. Since the individual sweeteners in combination with sugar was compared and optimized as shown in the previous paragraphs , and the finally selected combinations are compared in this table , no critical difference are compared in this table , no critical difference were observed between the sweeteners and control samples . Hence these combination were selected for further studies and final chemical composition.

Table.16.Sensory evaluation of *Shrikhand* preparation by using selected sweeteners

Sensory parameters	Control 100% sugar	Aspartame	Sucralose	Saccharine
Colour & appearance	7.5	7.5	7.3	7.5
Sweetness	7.5	7.5	7.4	7.5
Flavour	7.6	7.4	7.4	7.4
Body & texture	7.4	7.5	7.5	7.6
Overall acceptability	7.5	7.4	7.6	7.4

Average of 3 trials

5.12. Rheological properties of *Shrikhand* preparation by using artificial sweetener

To understand the effect of incorporation of artificial sweeteners on rheological properties, the consistency, firmness and index of viscosity of the samples were measured by using a food texture analyzer and the results are presented in Table 17. and Fig 7,8 & 9 .The table shows , the consistency of control *Shrikhand* was 4.4 newtons.sec and the values increased marginally to 4.7 and 4.6 for the *Shrikhand* samples containing aspartame and saccharine respectively. The values increased further to 5.3 .The readings were found proportional to the sugar content in the product. Because control has 65gm of sugar by weight of chakka, aspartame and saccharine containing samples had 75% of sugar and sucralose had 50% of sugar. This clearly indicates that as sugar level decreased the firmness of *Shrikhand* increases. Miyani *et al* (1984) assessed the effect of sugar level on the consistancy of shrikhand and report that increase in sugar content in the product resulted in reduction in firmness. The Table.17 and Fig 8 shows the firmness of *Shrikhand* samples. The control sample has a firmness of 0.7N and firmness increased marginally when the sugar content was reduced to 75% of sugar in aspartame and saccharine containing samples. The firmness increased further to 0.82N when the sugar content was reduced to 50% in sucralose containing sample. The trend was in parallel to that of consistency the Fig. 9 shows that the viscosity index of *Shrikhand* decreases with decrease in sugar content in *Shrikhand.*

Table.17. Rheological properties of *Shrikhand* preparation by using artificial sweetener

Rheological properties	Control	aspartame	sucralose	Saccharin
Consistency(N.sec)	4.4	4.7	5.3	4.6
Firmness(N)	0.7	0.71	0.82	0.72
Index viscosity(N.sec)	0.54	0.49	0.52	0.43

Average of 3 trials

Fig .7. Consistency of *Shrikhand* prepared using artificial sweeteners

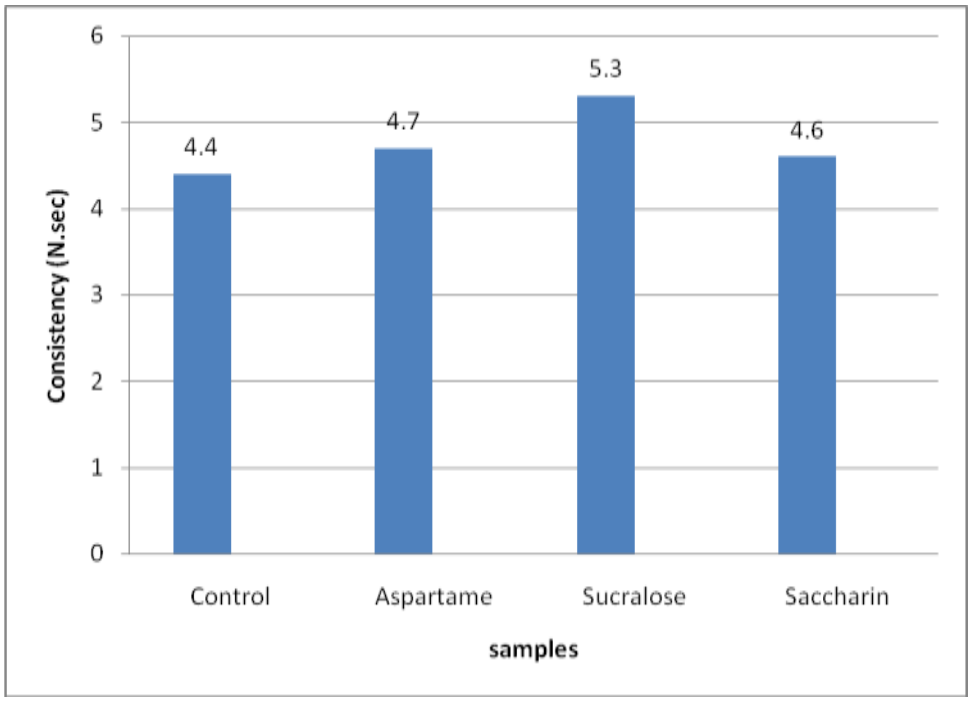


Fig .8. Firmness of *Shrikhand* prepared using artificial sweeteners

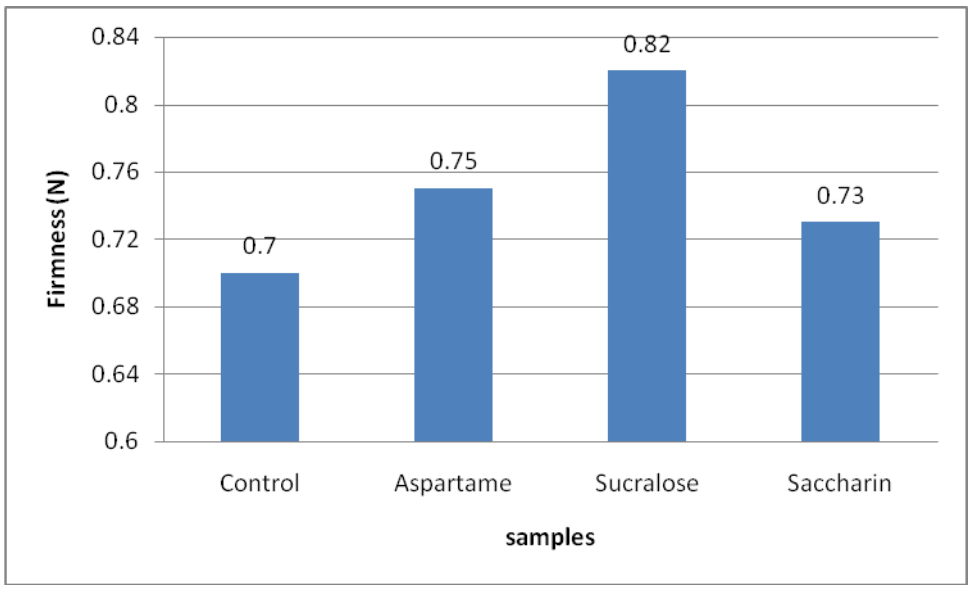
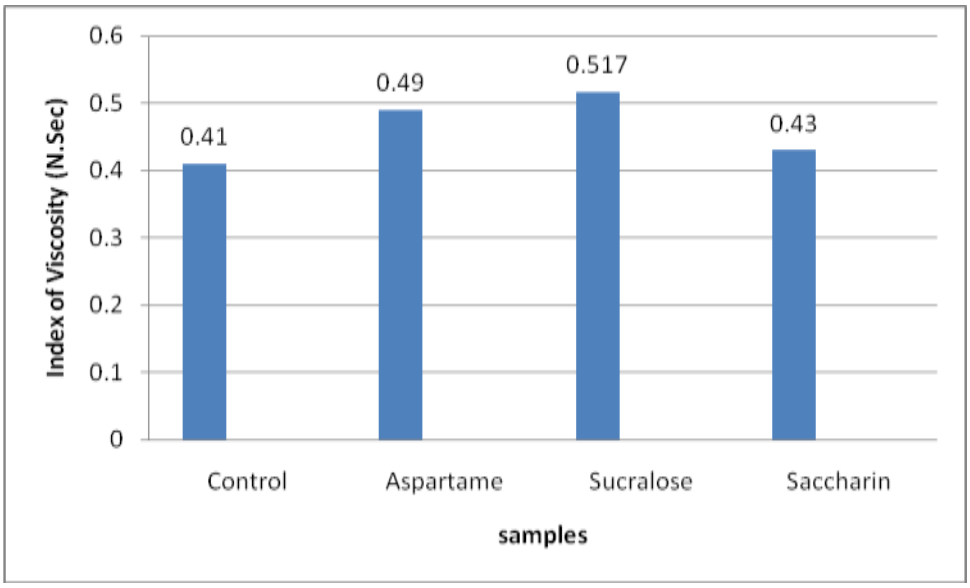


Fig.9. Index of Viscosity of *Shrikhand* prepared using artificial sweeteners



5.13 Effect of thermization on sensory quality of *Shrikhand*

Attempts were made to see the effect of thermization on sensory quality of the product prepared by using different sweeteners and the sensory scores are presented in Table.18. The colour and appearance scores indicate that the scores for non-thermized samples varied between 7.0 and 7.3 while those for thermized samples prepared by different sweeteners varied between 7.0 and 7.5. This shows that there was slight improvement in the colour and appearance of the product after thermization. This could be due to uniform distribution sugar after heat treatment and improvement in glossy appearance. Similarly sweeteners of all the samples before thermization varied between 7.0 and 7.3 and improved slightly (between 7.0 and 7.5) Similarly it was found that the flavour, body and texture, and overall acceptability scores improved marginally but not significantly when the *Shrikhand* samples were thermized.

Table.18. Effect of thermisation on sensory quality of *Shrikhand.*

Samples		Appearance	Sweetness	Flavour	Body & Texture	Overall acceptability
Control	Treatment1	7.3	7.1	7.1	7.0	7.0
	Treatment2	7.5	7.5	7.2	7.3	7.2
	t-value	-0.378^{NS}	-0.200 ^{NS}	-0.48 ^{NS}	-0.756 ^{NS}	-1.835 ^{NS}
Aspartame	Treatment 1	7.1	7.0	7.1	7.0	7.0
	Treatment 2	7.0	7.0	7.2	7.3	7.4
	t-value	-0.5 ^{NS}	-2.0 ^{NS}	-0.48 ^{NS}	-3.786 ^{NS}	-6.5 *
Sucralose	Treatment 1	7.1	7.3	7.0	7.0	7.1
	Treatment 2	7.3	7.5	7.1	7.5	7.6
	t-value	-1.0^{NS}	-1.0^{NS}	-1.8 ^{NS}	-5.0*	-6.5*
Saccharin	Treatment 1	7.0	7.1	7.1	6.5	6.9
	Treatment 2	7.4	7.4	7.1	7.2	7.2
	t-value	-5.5*	-1.4 ^{NS}	-1.5 ^{NS}	-1.9 ^{NS}	-2.0 ^{NS}

Average of 3 trials

*: Significance at 5% level NS : Non Significance at 5 %level

Treatment 1: Non Thermisation, Treatment 2: Thermisation

5.14 Storage studies of *Shrikhand* stored at 37^{o}C

The thermized *Shrikhand* samples prepared by using different sweeteners stored at 37^{o}C and the flavour and body & texture scores of the samples evaluated at 24hr intervals are presented in Table.19. The flavour scores of fresh samples varied marginally between 7.5 and 7.7. The scores remained almost static during 3 days of storage. At the end of 3 days of storage, the scores varied between 7.1 and 7.3 and the variation in score was not significant. At the end of 4 days the scores slightly reduced between 7.0 and 7.1 and remained static even at the end of 4 days of storage. The study indicates that the thermized samples can be stored well beyond 5days of storage at 37^{o}C .But the samples were discarded after 5days in the present

study due to appearance of surface mold which could have entered the product as post processing contaminant. If proper packaging system is adopted, *Shrikhand* can be stored beyond 5days.

Similar trend was seen in body and texture scores. The fresh *Shrikhand* samples had a uniform body and texture score of 7.5 and the at the end of 5days of storage the score ranged between 6.8 and 7.1 for different *Shrikhand* samples .But the difference was not significant.

The study indicates, all the artificial sweeteners behaved similar to sugar during storage period and hence can be used in the production of *Shrikhand.*

Table.19. Sensory score of *Shrikhand* stored at 37^{o}C

Sample	Days	control	Aspartame	Sucralose	Saccharine	Mean
Flavour	0	7.6	7.5	7.7	7.5	7.5^{a}
	1	7.4	7.3	7.5	7.3	7.4^{ab}
	2	7.4	7.2	7.3	7.2	7.3^{ab}
	3	7.3	7.1	7.2	7.1	7.1^{ab}
	4	7.0	7.1	7.1	7.1	7.0^{b}
	5	7.0	6.7	7.0	7.0	7.0^{b}
		CD $^{0.05}$				0.48
Body and Texture	0	7.5	7.5	7.5	7.5	7.5^{a}
	1	7.3	7.3	7.3	7.3	7.3^{ab}
	2	7.1	7.1	7.2	7.2	7.1^{b}
	3	7.1	7.1	7.2	7.1	7.1^{b}
	4	7.0	7.0	7.2	7.1	7.0^{b}
	5	6.8	6.8	7.0	7.1	6.9^{b}
				CD$^{0.05}$		0.45

Average of 3 trials

Figure with different superscripts in a row are significantly different at P≤0.05

ANOVA TABLE

Source	df	Body		Flavour	
		MSS	F Value	MSS	F Value
Days	5	0.795	3.346*	0.734	5.3*
Samples	3	0.074	0.312^{NS}	0.057	0.412^{NS}
Error	15	0.592		0.138	
Total	24				

*: Significance at 5% level NS: Non Significance at 5 %level

Fig .10. Flavour scores of *Shrikhand* stored at 37^{o}C

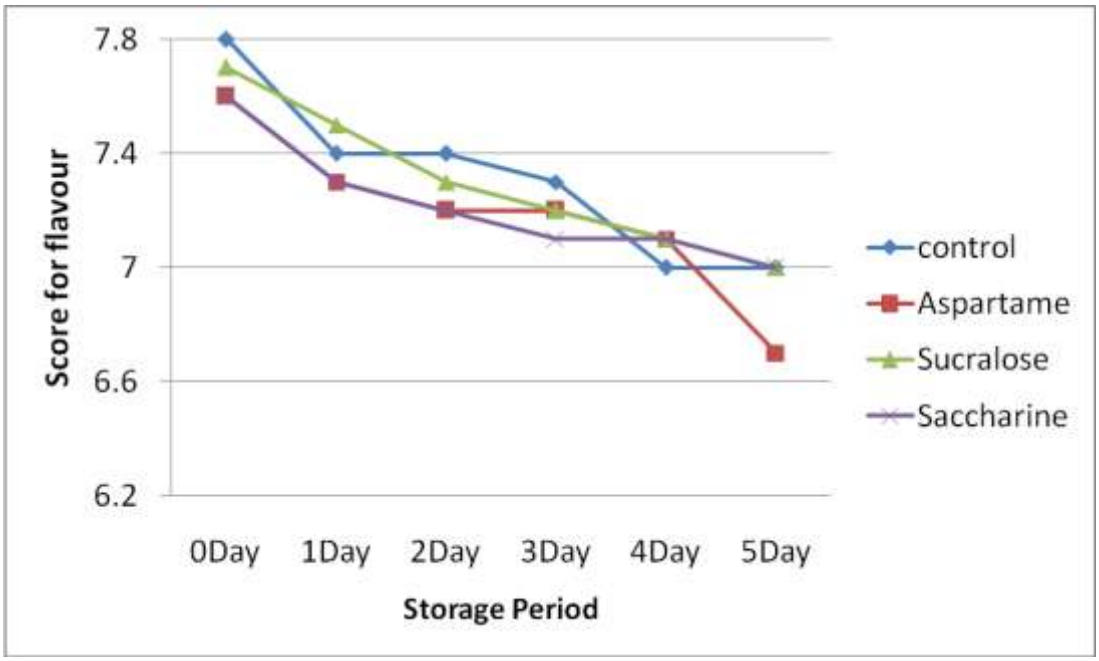
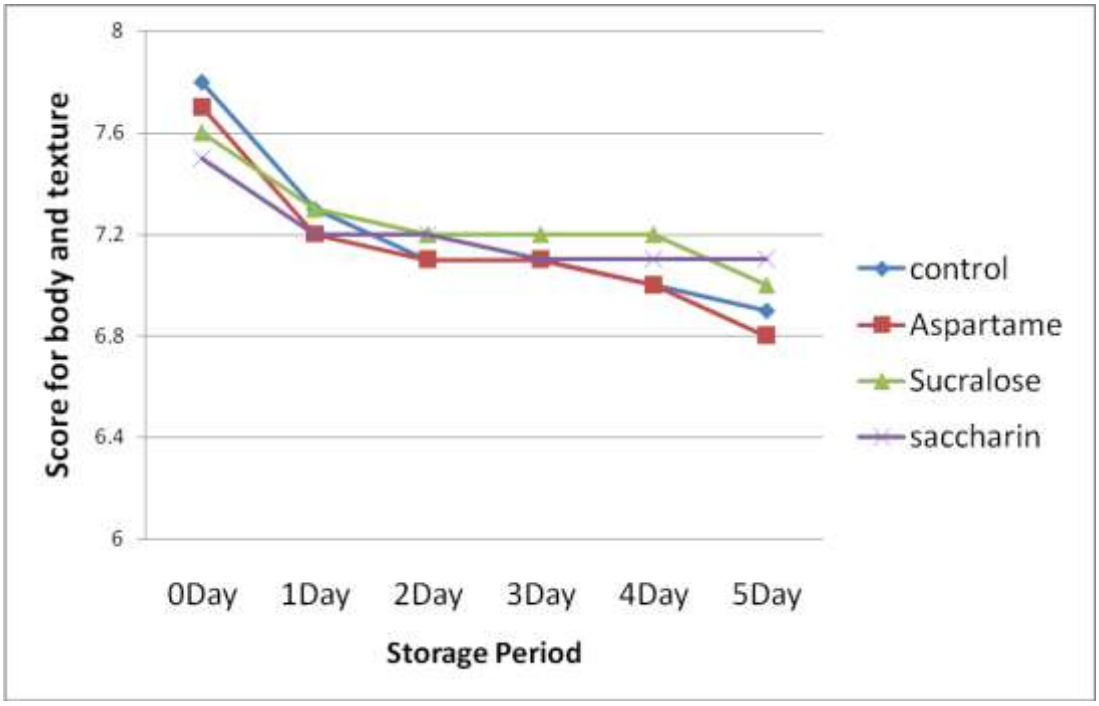


Fig .11. Body and Texture scores of *Shrikhand* stored at 37°C



5.15 storage studies of *Shrikhand* stored at refrigerated temperature

The thermized *Shrikhand* samples were stored at refrigerated temperature and evaluated for flavour and body & texture changes during storage period. The results are presented in Table 20 and Fig 12 and 13. The results shows that , the flavour scores in fresh samples varied marginally between 7.5 and 7.7 the scores improved at the end of 7 days of storage and varied between 7.8 and 8.1 this could be also to attainment of equilibrium in the consistency and improved blend of sweeteners and dahi flavour. Then the scores reduced in the range of 7.1 and 7.2 at this stage the product was commented to have slight stale flavour. However the samples were well accepted and no differences were observed between the samples. The scores showed downward trend till the end of 30days of storage. At the end of 30days , the samples scored this flavour scores ranged between 6.2 and 6.3, indicating the samples were slightly acceptable at this stage the samples had pronounced stale flavour .

Similar trend was observed in body and texture scores during storage period the body & texture of all the fresh samples scored a uniform score of 7.5 and

the scores varied between 7.8 and 8.1 this could be due to improved and homogenous consistency. The sugar melted and equilibrated during first weak of storage. The scores reduced at the end of 14 days of storage and varied between 7.1 and 7.3. The samples became slightly harder which could be due to increased bondage sugar molecules at lower temperature and slight evaporation of moisture. The scores reduced further with storage period. At the end of 30days of storage, the scores varied marginally between 6.2 and 6.3.

The trend of both flavour and body texture scores indicate that, the scores improved first week of storage and reduced with storage period. However the variation between the samples was very marginal and non significant between the samples but the variation was significant between the storage period.

Table.20 .Sensory scores of *Shrikhand* stored at refrigerated temperature

	Days	control	Aspartame	Sucralose	Saccharine	Mean
Flavour	7	8.0	7.8	8.1	8.0	7.9^{a}
	14	7.2	7.1	7.2	7.2	7.1^{b}
	21	6.8	6.8	6.5	6.6	6.6^{c}
	25	6.6	6.4	6.3	6.5	6.4^{cd}
	30	6.4	6.3	6.3	6.4	6.3^{d}
	$CD^{0.05}$					0.24
Body and Texture	7.	8.0	7.8	8.1	8.1	8.0^{a}
	14	7.3	7.1	7.3	7.3	7.2^{b}
	21	7.0	6.8	7.0	7.1	6.9^{b}
	25	6.5	6.4	6.4	6.4	6.4^{c}
	30	6.3	6.3	6.2	6.3	6.2^{c}
	$CD^{0.05}$					0.34

Average of 3 trials

ANOVA TABLE

Source	df	Body		Flavour	
		MSS	F Value	MSS	F Value
Days	5	8.472	3.346*	8.039	105.8*
Samples	3	0.141	0.312^{NS}	0.031	0.41^{NS}
Error	15	0.039		0.075	
Total	24				

*: Significance at 5% level NS: Non Significance at 5 %level

Fig .12. Flavour scores of *Shrikhand* stored at refrigerated temperature

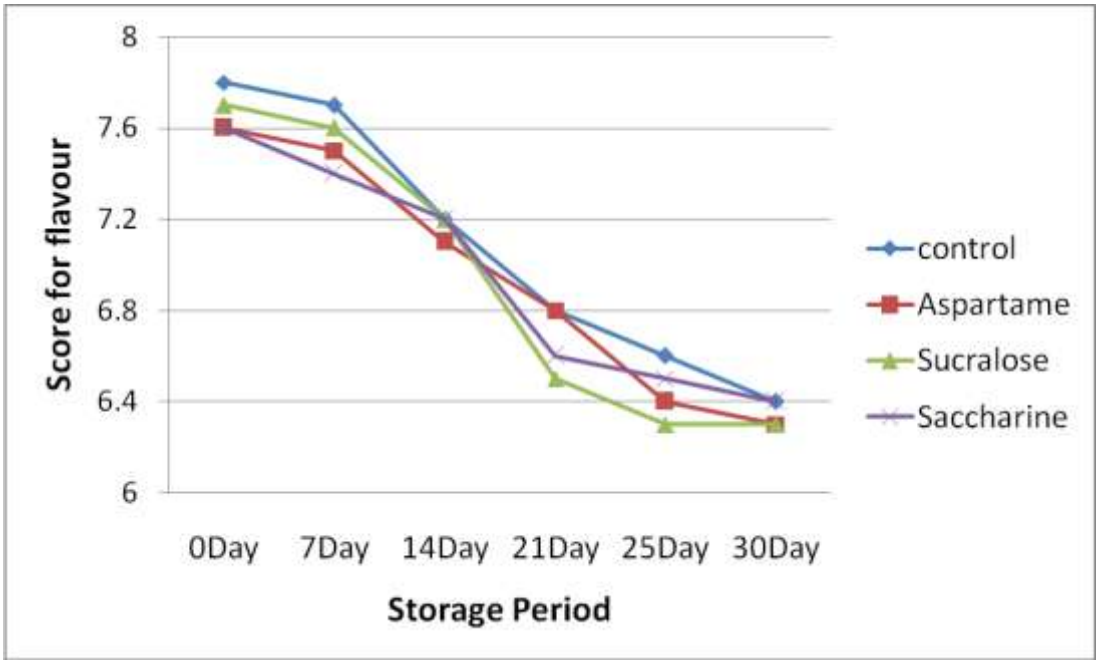
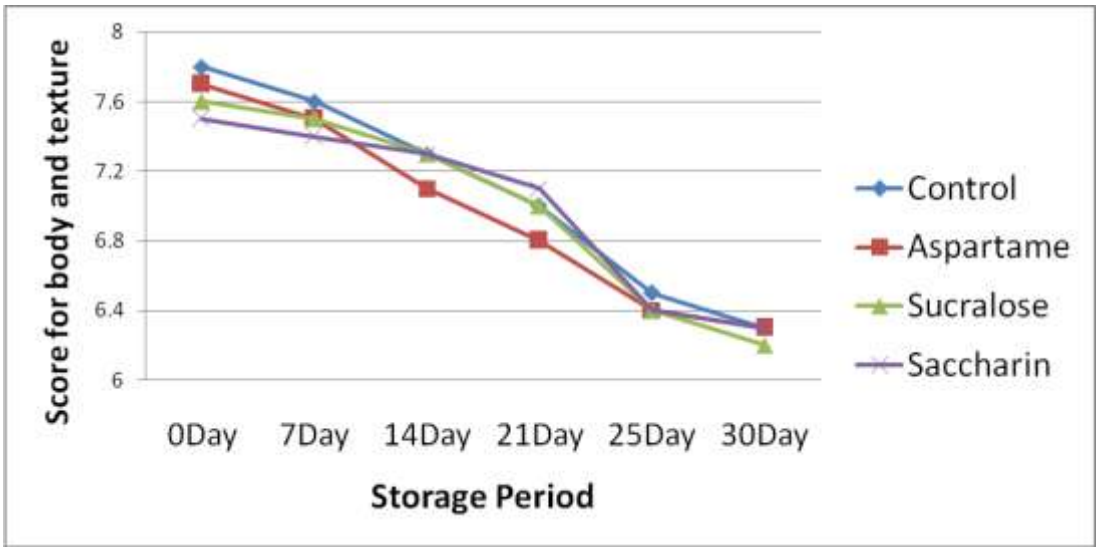


Fig .13. Body and Texture scores of *Shrikhand* stored at refrigerated temperature



5.16 Microbial quality of stored *Shrikhand* samples stored at 37^{o}C

The yeast and mold and coliform counts in *Shrikhand* samples stored at 37^{o}C were evaluated at the end of 24hrs and the results are presented in Table .16. the results indicates that , yeast and mold and coliform counts of all the fresh samples including control remains stable till the end of 4days of storage This indicates the thermization time temperature is sufficient enough to destroy yeast and mold & coliform in the samples. At the end of 5day of storage the samples showed slight increase in their count in all the samples. This increase in counts could be due to growth and multiplication of injured cells which could have reequipped during 4 day of storage and multiply after that .However the increase in growth was very slow which could be due to the samples. In any case the counts were within the BIS standards.

Table.21. Microbial count in Thermized *Shrikhand* stored at 37^{o}C

Samples	Days	Yeast and Mould(cfu/gm)	Coliform (cfu/gm)
Control	0	<10	<10
	1	<10	<10
	2	<10	<10
	3	<10	<10
	4	<10	10
	5	10	20
Aspartame	0	<10	<10
	1	<10	<10
	2	<10	<10
	3	<10	<10
	4	<10	<10
	5	10	10
Sucralose	0	<10	<10
	1	<10	<10
	2	<10	<10
	3	<10	<10
	4	<10	<10
	5	20	<10
Saccharin	0	<10	<10
	1	<10	<10
	2	<10	<10
	3	<10	<10
	4	<10	<10
	5	30	<10

5.17 Microbial quality of *Shrikhand* samples stored at refrigeration temperature

The thermized *Shrikhand* samples were stored at refrigerated temperature (6-8^{o}C) till the end of 30day and analysed for yeast & mold and coliform counts at regular intervals. The counts are presented in Table.17. As in case of the samples stored at refrigerated temperature also showed the counts of <10cfu/gm each in fresh and stored control samples and experimental samples. At the end of 30days of storage slight increase in yeast and mold counts were observed in all the samples. The coliform count was <10cfu/gm in control Shrikhand and *Shrikhand* prepared by using sucralose. The *Shrikhand* samples prepared by using aspartame and saccharine had the counts of 20 and 30cfu/gm respectively. But the counts were not high enough to bring about the spoilage of the product. The counts of both yeast and mold and coliforms were well within the BIS standards.

Table.22. Microbial count in Thermized *Shrikhand* stored at refrigeration Temperature

Samples	Days	Yeast and Mould(cfu/gm)	Coliform (cfu/gm)
Control	0	<10	<10
	7	<10	<10
	14	<10	<10
	21	<10	<10
	25	<10	<10
	30	10	<10
Aspartame	0	<10	<10
	7	<10	<10
	14	<10	<10
	21	<10	<10
	25	10	<10
	30	20	20
Sucralose	0	<10	<10
	7	<10	<10
	14	<10	<10
	21	<10	<10
	25	<10	<10
	30	10	20
Saccharin	0	<10	<10
	7	<10	<10
	14	<10	<10
	21	<10	<10
	25	<10	10
	30	20	30

5.18 Chemical composition of *Shrikhand*

The chemical composition of control and experimental Shrikhand samples were analyzed and the results are presented in Table 23. The Total Solids in control sample was 58.72% while that in Sucralose used samples was 47.56% and in aspartame and saccharine used samples, it was 50.96 and 50.84% .The decrease in TS in aspartame and saccharine used samples was nearly 10% less than control sample. This was mainly due to 25% reduction in sugar addition compared to control *Shrikhand.* In sucralose used sample the reduction in TS was nearly 20% where 50% of normal sugar was added. The TS content in experimental samples was not conforming to PFA standards .

Table.23. Chemical composition of *Shrikhand*

	Control	Aspartame	Sucralose	Saccharin
TS (%)	58.72	50.96	47.56	50.84
Fat (%)	10.48	11.65	12.9	11.54
Protein (dry matter basis) (%)	9.86	9.68	10.75	9.62
Lactose (%)	2.23	2.13	2.46	2.34
Sucrose (%)	38.65	31.56	24.5	32.65
Ash (%)	0.46	0.62	0.56	0.61
Acidity (% LA)	0.99	1.17	1.3	1.17
Aw	0.903	0.929	0.925	0.946

The fat content in control sample was 10.48 and in aspartame and saccharine used samples it was 11.65 and 11.54% respectively, while in sucralose used *Shrikhand* it was highest at 12.9. Similarly the protein content (on dry matter basis) in control and experimental samples reared b using aspartame, sucralose and saccharine was 9.86, 9.68, 10.75 and 9.62% respectively. The increase in fat and protein content in experimental samples was due to proportionate increase in chakka used resulted from lesser use of cane sugar in these samples. As expected, the sucrose content in control sample was 38.65% while in aspartame and saccharine used *Shrikhand* it was 31.56 and 32.65% respectively. The sucrose content was least in sucralose.

6.0 SUMMARY AND CONCLUSION

With the awareness in consumers about the calorie intake, the demand for low calorie foods increasing steadily the latest amendments made in PFA rules permits selected artificial sweeteners in milk based foods. This has opened a new area in the dairy processing to replace the sugar partially or completely depending on the maximum levels of sweeteners permitted by PFA and getting desirable flavour and body & texture in the product. In this direction attempts were made to incorporate the selected artificial sweeteners in *Shrikhand* and study their effect on quality of *Shrikhand* . The findings of the investigation are summarized in the following paragraphs.

6.1 The *Shrikhand* prepared by using 9.0% SNF was found to better accepted with clean flavour use of higher level of SNF in skim milk resulted in powdery flavour and slight grain texture.

6.2 Shrikhand prepared by using chakka containing 1.6% LA was better accepted than that made from chakka with 2.0% LA the latter product to had more sourness.

6.3 The studies on optimization of sugar level in *Shrikhand* showed that use of 65% of cane sugar (on chakka basis) was best accepted. Use of lower level of sugar significantly reduced both flavour and body and texture quality of *Shrikhand.*

6.4 The use of fermented cream was found to improve the overall sensory quality of *Shrikhand* sample .The fermented cream was found to boost the delicate combination of sweet & sour flavour in the product.

6.5 Studies on use of sucralose in *Shrikhand* preparation revealed that at the maximum permitted level of 750ppm of the sweetener .The desired sweetness, body & texture could not be obtained in *Shrikhand* .

6.6 Studies on use of aspartame also showed that desired flavour and body & texture in Shrikhand cannot be obtained even when the maximum permitted level of 200ppm of the sweetener was used in the product.

6.7 Similar findings were obtained when saccharine was used as sweetener even at the maximum permitted level of 500ppm the sweetener, The desired sensory attributes cannot be obtained.

This shows that the sweeteners alone cannot gives desired quality to the product and needs a combination of sugar.

6.8 The *Shrikhand* prepared by using 750ppm of sucralose combination with 50% of sugar (used for control sample) , was found to have almost identical sensory qualities compared to those in *Shrikhand* prepared by using cane sugar.

6.9 The sensory quality of *Shrikhand* prepared by using 200ppm of aspartame and 75% of sugar was very well comparable to control *Shrikhand* .

6.10 Similarly the sensory quality of *Shrikhand* prepared by using 500ppm of saccharine and 75% of sugar was well comparable with control sampler.

6.11 The rheological studies indicate that consistency, firmness and index of viscosity of Shrikhand prepared by using sucralose were higher when compared to control. However these parameters of *Shrikhand* prepared by using aspartame and saccharine were comparable to control *Shrikhand*.

6.12 Thermisation of *Shrikhand* was found to improve the sensory quality marginally. However the improvement was not significant.

6.13 The storage studies of *Shrikhand* prepared by using different sweeteners showed that all the samples including control stored well beyond 5days of storage at 37^{o}C , artificial sweeteners tried , behaved similar during storage .

6.14 When the *Shrikhand* samples stored at refrigerated temperature (6-8^{o}C) all the sample stored well upto 30days. After that all the samples developed stale flavour and body become firmer.

6.15 The microbiological studies of samples stored at 37^{o}C revealed that even at the end of 5days of storage, the yeast and mold and coliform counts were well within the acceptable levels. When the samples were stored at refrigerated temperature the counts were within the acceptable levels even at the end of 30days of storage.

6.16 The chemical analyses of the *Shrikhand* samples prepared by using artificial sweeteners was much below the level of 58% prescribed by PFA. However the protein, fat, ash, and sugar contents were well within the PFA prescribed limits.

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