DEVELOPMENT OF WHEY-MILK BEVERAGE

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

MASTER OF TECHNOLOGY
IN
DAIRYING
(DAIRY TECHNOLOGY)

BY
ANIL KUMAR

DIVISION OF DAIRY TECHNOLOGY
NATIONAL DAIRY RESEARCH INSTITUTE
(I.C.A.R.)
KARNAL - 132 001 (HARYANA), INDIA
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All

Those Who Shared

My

Good & Bad Times

With

Encouraging Smiles

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MASTER OF TECHNOLOGY
IN
DAIRYING
(DAIRY TECHNOLOGY)

Approved by

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Dated: 18th June, 2001

CERTIFICATE

This is to certify that the thesis entitled **"DEVELOPMENT OF WHEY-MILK BEVERAGE"** submitted by **Mr. ANIL KUMAR** towards the partial fulfilment of the requirement for the award of the degree of **MASTER OF TECHNOLOGY (DAIRYING)** in **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.

(Dr. B.D. TIWARI)
MAJOR ADVISOR & CHAIRMAN
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Dated: 18th June, 2001

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18/6/01

(ANIL KUMAR)

Abstract

Whey is a nutritious product that has been often wasted and discarded. In the last quarter century nutritive components of whey have been identified and have found many food applications. Whey based beverages are characterized by their high nutritional value due to the presence of lactose, proteins and mineral components. This investigation was, therefore, undertaken with the objectives of developing suitable technology for the manufacture of whey-milk beverage and cultured whey milk leverage and ascertain their shelf stability.

The study revealed that a good quality whey-milk beverage and cultured whey-milk beverage could be made from a mixture of whey and milk. Admixing of 80 percent cheddar cheese whey or 70 percent paneer whey with milk yielded an acceptable whey-milk beverage. However, the paneer whey required neutralization before use in the beverage. Use of 0.075 percent level of stabilizer, guar gum, improved the consistency of the whey beverage made from both types of whey. Cultured whey milk beverage made from a mixture of cheese whey and milk was more acceptable than that made from paneer whey-milk mixture. However, only 70 percent cheese whey could be used for the manufacture of an acceptable cultured whey-milk beverage product. The overall acceptability of cultured whey-milk beverage improved with the addition of carboxymethyl cellulose at the rate of 0.3% of the product. The performance of CMC was considered to be the best in comparison to pectin and guar gum. The storage study showed that the paneer WMB kept well upto 9-days, cheese WMB remained good for only up to 6-days. Cultured WMB kept well upto 6-days.

सारांश

व्हे एक पोषक पदार्थ है जो अक्सर व्यर्थ व फैंक दिया जाता है । गत 25 वर्षों में व्हे के पोषक अव्यवों को पहचाना गया है तथा इनकी कई खाद्य अपयोगिताएँ भी पाई गई हैं । लेक्टोज़, प्रोटीन व मिनरल के कारण व्हे आधारित पेय उच्च पोषण वाले खाद्यों के रूप में चरित्रीकृत किए जाते हैं । यह अन्वेषण इस उद्देश्य से लिया गया कि व्हे-दुग्ध पेय तथा संवर्धित दुग्ध पेय के निर्माण के लिए उपयुक्त प्रौद्योगिकी विकसित की जा सके तथा उनकी निधानी स्थिरता सुनिश्चित की जा सके ।

अध्ययन से ज्ञात हुआ कि एक अच्छी गुणवत्ता का व्हे पेय तथा संवर्धित व्हे-दुग्ध पेय, व्हे व दूग्ध के मिश्रण से बनाया जा सकता है । चैडर चीज़ व्हे का 80 प्रतिशत अथवा पनीर व्हे का 70 प्रतिशत दुग्ध के साथ मिश्रण करने पर स्वीकार्य व्हे-दूग्ध पेय प्राप्त किया जा सकता है । किन्तु पनीर व्हे को पेय के लिए प्रयोग पूर्व अपभावीकरण आवश्यक था । 0.075 प्रतिशत गौर गम को स्थाईकारी के रूप में प्रयोग करने से दोनों व्हे से प्राप्त पेय की गाढ़ता में वृद्धि होती है । चीज़ व्हे-दुग्ध पेय जो चीज़ व्हे व दुग्ध ा के मिश्रण से बनाया गया, पनीर व्हे मिश्रण से अधिक स्वीकार्य था । किन्तु 70 ्रतिशत चीज़ व्हे को ही संवर्धित दुग्ध-व्हे उत्पाद के निर्माण के प्रयोग लिए स्वीकार्य किया जा सका । संवर्धित व्हे-दुग्ध पेय की कुल स्वीकार्यताएँ, 0.3 प्रतिशत कार्बोक्सी मिथाईल, सेल्यूलोज़ के डालने पर वृद्धि हुई । पैक्टिन व गौर गम की तुलना में सी-एम-सी के परिणाम बेहतर थे । भंडारण अध्ययन से ज्ञात हुआ कि पनीर व्हे-दुग्ध पेय 9 दिन तक तथा चीज़ व्हे-दुग्ध पेय 6 दिन तक अच्छी अवस्था में रखा जा सका । संवर्धित व्हे- दुग्ध पेय 6 दिन तक रखा जा सका ।

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CHAPTER-1

INTRODUCTION

1. INTRODUCTION

India's success in dairy development is now internationally acknowledged. India, as a result of phenomenal growth of 4.7 per cent per annum in milk production since 1971, has emerged as the largest producer of milk in the world. A large proportion of milk (%) is converted to various milk products like milk powder, ghee, butter and fermented and coagulated milk products. Earlier, conversion of surplus milk into milk powder and ghee formed the major activity of organized dairy industry in India. But now a considerable portion of milk is being diverted to the manufacture of cheese, paneer, chhana, casein and other coagulated milk products.

In the production of cheese, paneer, and chhana only 10-20 per cent of milk is recovered as the desired end product and the remaining 80-90 per cent as whey. Whey contains about 6.4 – 7.0% dry matter which accounts for 45-50% of all the milk constituents. Whey contains 70% of the milk sugar (lactose), 20% milk proteins, 70-90% of milk minerals and almost all the water-soluble vitamins originally present in milk. Whey is a major source of energy giving lactose, good source of minerals e.g. calcium and phosphorus also water soluble vitamins. Whey proteins are one of the best quality proteins available, which possesses high protein efficiency (PER-3.6%), biological value (BV-104) and net protein utilization (NPU-95), and have almost all the essential amino acids. (Khamrui, K, 2000).

Investigations established that the whey solids have excellent nutritional value.

It is estimated that about 3-million tons/annum of whey is generated in India, which contains about 2 lakh tons of precious milk constituents. At present almost all the whey produced in the country is drained into gutters.

Whey is also a most potent pollutant of all dairy wastes, as it possesses high organic content contributing to high Biological Oxygen Demand (BOD_5, 45000-60,000 ppm).

Environmental control legislation and growing concern over pollution has compelled the Dairy Industry to discontinue dumping of whey into streams and municipal sewage systems. However, the treatment of whey before disposal is very costly affair. Therefore, there has been a greater emphasis all over the world on the utilization of whey solids in different ways.

Consequently, exhaustive research investigations have been carried out to explore the ways of whey utilization in various forms. Unfortunately none of these technologies has been well accepted by the Indian Dairy Industry probably due to the high cost of production and limited market of resulting products. Therefore development of strategy to harvest and conserve whey solids is the urgent need of the day. The mode of utilization should be most economical and convenient.

The diversion of whey solids to human food chain employing cost effective technologies appears to be the best alternative to utilize whey. However, conversion of whey into beverages through fermentation or without fermentation is one of the most attractive avenues for the utilization of whey for human consumption. The market

demand for beverages and instant foods is growing all over the world and India is not any exception to it. Also pre-eminence of whey as a beverage has been recognized as it is a genuine thirst quencher, light, refreshing, healthful and nutritious (Prendergast, 1985). Several authors have reviewed the utilization of whey as the base for the preparation of wide varieties of palatable beverages and suggested that whey could be used in the formulation of nutritive soft drinks (alcoholic or non-alcoholic) or high protein beverages .It could also be used with the addition of fruit juices. Hence development of a formulated whey-milk beverage may open-up a good market opportunities particularly in India.

The present study is, therefore, undertaken with the following objectives to explore the possibility of utilization of cheese whey for manufacturing whey – milk beverage/drink. Such a product is expected to provide a soft drink, which would be opening up scope for utilization of whey in a profitable manner, which is otherwise discarded.

OBJECTIVES

- To standardize a process for the manufacture of Whey-milk beverage (WMB).
- To study sensory and physico-chemical attributes of WMB.
- To evaluate storageability of the WMB.

CHAPTER-2

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Whey is the by-product obtained during the manufacture of cheese, paneer, chhana and other coagulated dairy products. Although It contains 6-7% of milk solids, it is commonly considered as a waste product because of its low concentration of milk constituents (Sienkiewicz, and Riedel, 1990). Comparison of the gross composition of milk and representative whey samples reveals that it contains about 50-55% of total milk solids, 70% of milk sugar, 20% of milk proteins, 70-90% of minerals and almost all the water soluble vitamins (Rao *et al.*, 1999). Whey constitutes about 80-90% of the volume of milk and its physico-chemical characteristics varies according to the type of product from which it is derived. (Kosikowski, 1979; Bhattacharyajee, 1993; Sachdeva *et al.* 1998).

2.1. WHEY TYPES AND THEIR COMPOSITION

Depending on the method of recovery whey obtained during casein and cheese production may be divided into rennet whey, acid whey or technical whey. The whey intended for industrial processing is given the designation "Industrial Whey".

Also depending on the end product required - acid casein, rennet casein, co-precipitate, cottage cheese, quarg and fresh cheese, or thermoquarg and rennet cheese - whey may also be differentiated according to their protein, fat, ash, lactose and lactic acid contents. The composition of the whey changes according to the type of milk used for the product (Tadeusz and Riedel, 1990). In Germany, rennet and acid whey have been defined since 1987 (Anon, 1988).

2.1.1.RENNET WHEY

Rennet whey is the milk serum obtained by separation of casein, effected predominantly by rennet, but β-galactosidase can also be used. The liquid by-product (rennet whey) obtained during the manufacture of rennet cheese, after precipitation of the casein and milk fat can be used for further industrial processing. The total solids, fat and protein content of cheese whey is more than that of acid whey (Bhatacharyajee, 1993), but there is higher amount of calcium, phosphorus and lactic acid in acid whey as compared with the sweet whey (Kosikowski, 1979).

The average physico-chemical properties of cheddar cheese whey are pH 6.2-6.4, titratable acidity (%LA) 0.16-0.18, specific gravity 1.021-1.077, total solids 6.2-6.4%, lactose 4.75-5.1%, protein 0.8-1.0%, fat 0.06-0.12% and ash 0.55-0.62% (Jayaprakasha, 1992; Durham *et al.*, 1997).

2.1.2.ACID WHEY

Acid whey is the milk serum obtained by separation of casein, effected predominantly by acid, but also by use of β-galactosidase. Depending on the type of precipitation e.g. precipitation with lactic acid or mineral acids, the whey can also be divided into acid whey or industrial whey (pH 3.9-4.5); both of which contain less lactose and protein than rennet whey. On an average the acid whey contains protein 0.8-1.0%; lactose-3.8-4.3%; total solids 5-6%, and minerals 0.5-0.7 percent.

In rennet whey 0.5% of a 0.9% total nitrogen and in acid whey 0.6% of a 0.9-1.0% total-nitrogen is coagulable with heat (Webb and Whittier, 1970). A further significant difference between rennet and acid whey concerns their respective calcium, phosphorus and potassium contents. In acid whey, part of the calcium is present as lactate in solution, but in rennet whey ca-

lactate is either completely absent or present only in traces. Calcium is generally separated out of rennet whey together with the para-κ -casein complex. Acid whey contains a lower proportion of soluble nitrogen than rennet whey. Acid whey also shows lower amount of lactose content (3.8-4.2%) than rennet whey (5.01%). Rennet and acid whey have the most varied fields of application, while casein whey, is mainly used after drying for feeding applications.

Whey does not keep well for a long time. It can be rendered useless even after 48 hrs for lactose production by the action of the remaining LAB (optimum temperature 20-40°C). If whey is to be stored it should be heated after separation of casein at a temperature of 72°C-74°C for a short period (15-40 Sec) followed by cooling to 3-4°C. The milk clotting enzymes present in whey are inactivated by pasteurization Branner-Jorgensen *et al.*(1981) reported the residual activity of Mucor-mihei rennet in whey heated at 72°C was 70%, while it was only 40% in the whey which was heated at 74°C.

2.2. SIGNIFICANCE OF WHEY

It contains half of the nutritive milk solids which make it so important. Whey has got whey proteins, lactose, minerals and almost all the water-soluble vitamins. Each one of these constituents have their own importance because of their nutritive, therapeutic and functional properties.

2.2.1. NUTRITIONAL PROPERTIES

The most valuable component of whey is the protein which is most effective in meeting the body's energy and amino-acid requirements and is more superior than the proteins available from other sources (Werner, 1981; Belem *et al.*, 1999). The individual components of whey proteins such as α-lactalbumin is

used in humanized infant food formulations, whereas, β-lactoglobulins are used in sports and dietetic beverages (Durham *et al.*, 1997).

Lactose in whey is a suitable substrate for acidophillic flora in the intestine to inhibit the growth of basophilic and putrefying micro-organisms. Lactose as compared to sucrose has low sweetness and low glycemic index and promote healthy intestinal flora (Lifran *et al*; 2000).

2.2.2. THERAPEUTIC VALUE

Whey and whey-based products have relatively high lactose content which forms a suitable substrate for probiotics in the intestine (Renner, 1992). Lactose if included in diet, absorption of calcium can be considerably improved. Reports suggesting prophylactic effect of whey against tuberculosis and arthritis are also available in literature (Holsinger *et al.*, 1974).

Recent reports claim that the whey proteins have anticariogenic activity (McIntosh *et al.*, 1995). Whey also consists of lactoferrin which has antibacterial properties, lactoperoxidase enzyme that has anticariogenic activity, apart from immunoglobulins, active peptides and growth factors which stimulate cell growth (Bhatia, 1997; Durham *et al.*, 1997). Whey is helpful in curing Gastrointestinal disorder, anemia and liver problems etc. (Jelen, 1992).

2.2.3. FUNCTIONAL PROPERTIES

Apart from their nutritional and therapeutic advantages whey proteins exhibit excellent functional properties such as solubility, foaming, emulsifying, gelling and water binding etc. (Methews, 1984; Patel and Kilara, 1990). Whey shows wider range of functional characteristics contributing to flavour, colour,

texture and overall acceptability attributes in various varieties of foods (Marshall, 1995; Regester *et al.*, 1996).

Lactose especially α-lactose monohydrate is used in infant formula as energy source, in frozen and concentrated milks as protein stabilizers, in dry soups and sauces etc. for enhanced flavour, reduced sweetness and price advantage (Lifran *et al.*, 2000). In baked goods lactose is used extensively for promoting browning reactions without being fermented by bakers yeast (Zall, 1992).

2.3. WHEY UTILIZATION

Significant developments in the field of whey utilization have taken place in the last few decades as evidenced by the remarkable increase in the number of publications on this topic thereafter (Tadeusz and Riedel, 1990). The biologically highly nutritious whey protein content and the presence of mineral salts and vitamins make whey particularly attractive for many foodstuffs industries and the animal feed industries. In developed countries, most of the whey is used by different food processing industries. However, whey poses problems in its utilization because of its scattered production and low total solids concentration in India. As whey is very rich in organic matter content its disposal in the sewerage is the problem as the BOD_5 of whey is as high as 45,000-60,000 ppm. It is the most potent pollutant of all diary wastes (Smithers *et al.*, 1996). Enforcement of strict environmental regulations worldwide has encouraged dairy industry to reappraise whey disposal more specifically. At the same time treating whey before disposal to decrease its BOD value is costly and not economically viable. Durham *et al.* (1997) reported that treating 5 lac litres of whey in sewage could cost $ 10,000 per day for primary treatment or $1,45,000 for tertiary treatment. In addition,

disposal of whey in sewage also causes loss of valuable and nutritious milk solids.

Whey contains 93-94% water, hence, it is too bulky and creates problem during storage and handling. Also the high lactose content causes rapid increase in acidity of raw whey which compels for its utilization immediately after it is generated. At high temperatures (>60°C) the simple, measurable, irreversible denaturation is dependent on the time, protein concentration, pH value and ionic strength (Tadeusz & Riedel, 1990). Protein stability is the biggest challenge for its use in different products (especially in beverages). Whey is used in different forms. In recent past the isolation of individual whey constituents and their uses have also assumed a special significance. However, the best possible use would be to direct it back to the human food chain by employing different processes. Herrmann *et al.* (1988) reported conversion of whey by different processes to yield products like condensed whey, sweetened condensed whey, whey protein concentrate (WPC), alcohol, vitamin B_{12}, ammonium lactate etc.

Several attempts have also been made to utilize whey in different whey drinks/beverages, soups etc. Also there are various types of milk beverages tried so far like flavoured milk beverage, milk-like beverage, fortified milk beverage, chocolate milk, fermented milk beverage, fruit flavoured drinks etc.

The utilization of whey provides several advantages, such as

- It provides additional sales outlets for typical whey products such as whey proteins, whey cream, lactose and milk minerals,
- Opens up avenues for development of new whey products eg., Lactitol and

- reduces pollution from cheese factory effluent (Tadeusz and Riedel, 1990).

There is a greater thrust all over the world for utilization of whey in foods by employing most economical and convenient processes. Even milk-whey bath is suggested for retaining and replenishing the skin's protective acid layer. In Europe whey bath is prescribed for healing and restoring, dry, sensitive or damaged skin. Milk-whey is naturally cleansing and moisturizing agent. Skin feels hydrated, healthier, and more radiant (Anon, 1997).

2.4. PRESENT STATUS OF WHEY UTILIZATION

In India, with the increased cheese production, enormous quantity of whey is generated per year (3-MILLION TONS) (Khamrui and Rajorhia, 1998) and due to lack of technology/infrastructure, most of the whey is generally drained off to the sewerage.

NDDB (National Dairy Development Board) is seriously looking avenues for whey utilization, as they are the largest cheese manufacturers in India and facing the problems of whey disposal. Although extensive research work is in progress for commercial utilization of whey there are marketing problems of the products due to lack of awareness among people and unacceptable flavour of whey to Indian palate. Therefore there is tremendous scope for systematic approach for developing a whey-milk beverage to suit the Indian palate.

2.5. WHEY BEVERAGES

Whey which is called in Greek "Oros", has probably been used for centuries for the production of whey drinks and whey cheese. In last few decades, extensive investigations in the area

of whey utilization have revealed an increasing number of possible uses of whey protein in the foodstuffs industry.

One particular application of whey is in the production of different types of beverages. The use of whey for the production of special drinks e.g., *refreshing* drink, whey beer and whey champagne etc. has long been undertaken and investigated. Since not much work has been done on whey-milk beverage type products. The formulation of flavoured whey-milk beverage may be a timely solution to preserve the whey solids. The production of beverages from whole whey represents the most economically favorable option, as, apart from fat separation, pasteurization and the possible need to degas the whey, there only remains the necessity to aromatize.

In 1987 the Federal Republic of Germany considered whey drinks as mixed whey products for the first time and defined it. According to this definition whey drinks must contain, in liquid or solid form, more than 51% of whey constituents and may contain colouring food stuffs, milk protein products and β-galactosidase (Riedel, 1988). However, no such definition of specifications for whey drinks exists there in India at present.

Rennet whey, which serves predominantly as a basis for whole whey, has a neutral flavour. A whey-aftertaste can occur which does not represent a particular flavour defect but various flavour imperfections the causes for which may be lactic acid fermentation reaction between proteins and sugars, light reactions, protein degradation and oxygen influence. Neutralization of whey results in a change of all these flavour characteristics (Tadeusz and Riedel, 1990)..

2.5.1. FRUIT FLAVOURED BEVERAGES

Attempts were made by Singh *et al.* (1999) to develop a soft-beverage from paneer whey and guava. The guava whey beverage formulated by using Banarasi Surkh variety of guava extract and whey at 1:3 ratio with 8% sugar level and lemon colour scored highest on Hedonic scale rating. Singh *et al.* (1994) developed acceptable whey based Mango. Pineapple, Lemon and Banana beverages from paneer whey. Pulp or juice content ranged from 5% for lemon to 20% for pineapple and banana. Whey content of beverages ranged from 73-87%.

Vojnovic *et al.* (1993) made whey based beverages from pasteurized whey permeate with added fruit juice (20-40% Cherry, Apple, Grapes, Strawberry and Orange), sucrose (7-10%) and ascorbic acid (0.2-0.4%). High proportion of fruit juice resulted in highest sensory scores. Khamrui (2000) used cheddar cheese whey for the development of ready to serve Kinnow juice beverage. It was developed by mixing Kinnow juice concentrate (23° Brix by reverse osmosis) with concentrated fresh cheddar cheese whey (45% total solids) along with other ingredients (Sugar 7%, Pectin 0.05% and CMC 0.15%). This formulation when reconstituted with three times water gave a good beverage.

Gagrani *et al.* (1987) manufactured fruit based beverage using whey. They added different fruit juices like Orange, Pineapple and Mango at the rate of 10%, 15% and 15% respectively to whey. Mango based beverage was reported to be superior than others with respect to colour, flavour and mouthfeel and physical characteristics like sedimentation, turbidity, viscosity etc.

Most recently, Shukla *et al.* (2000) developed a ready to serve beverage from whey by the addition of 10% sugar and 30% litchi juice. Patel and Gupta (1982) developed a high-protein

whey drink by mixing heat-treated soybeans and cheese whey (low lactose). In the final product soy protein to whey protein ratio was kept 3:1.

Mathur *et al.* (1988) developed a method for manufacturing UHT-treated fruit whey Beverage. The beverage was made by coarse filtration of whey in which stabilizer was dispersed followed by gentle agitation for 30 minutes. Then it was pasteurized and cooled to 42°C for inoculation to reduce its pH to 4.3. Again it was cooled and flavour & sugar were added. Finally, it was heated to 65°C and homogenized at high pressure before UHT processing, packaging and storage.

Gandhi (1989) patented a process for the manufacture of Acido-whey which is a lactic fermented, non-carbonated whey drink retaining all the whey nutrients intact. This product has therapeutic value and is highly acceptable.

2.5.2.MILK-LIKE BEVERAGES

Downham (1914) patented a process for making a product resembling human milk by homogenization of sweet whey with cream, butter fat, milk sugar, skim milk and sodium citrate. Edmondson *et al.* (1968) developed a sterile milk-like beverage from sweet whey and cream. The product, condensed to 35% total solids and flavoured with chocolate, was sterilized by a standard HTST procedure, homogenized and canned aseptically. The reconstituted product 17.5% total solids scored 6.5 on a 9-point hedonic scale compared to 6.9 for commercial chocolated drinks.

An imitation milk beverage 'whey mil' was formulated from whey, selected vegetable oils, vegetable hydrocolloids and in some cases even skim milk. The beverage contained 2.4% fat and 1-15% protein. The fat, protein dispersion was claimed to be

physically stable for 3-4 weeks (Brunner *et al.*, 1969). Vajdi and Pereira (1973) reported the use of whey as milk substitute in the production of strawberry, lactose and chocolate beverages. The pH of whey was adjusted to 6.7 with 0.1 N KOH. Strawberry drink was prepared by addition of 2.59 kg of 35% fat cream, 2.27 kg of sugar, 2.72 kg of skim milk powder, stabilizers and flavours to 38 kg of liquid whey. The mixture was heated to 82°C for 2 minutes, homogenized at 35.2 and 10.5 kg/cm$^{2.}$ and cooled to 10°C before bottling.

Marhounova (1980) developed a formulation and manufacturing procedure for a heat-treated whey-beverage. Whey (82%) with 5-10% whey-suspension of Frimbion MD stablizer was heated to 75°C and cooled to 45°C. At this temperature Orange juice concentrate (3%) was added and the pH adjusted to 5.7-5.8 with citric acid. The beverage was again heated to 90°C, homogenized at 20MPa and hot filled. The product stored at less than 8°C had shelf life of 21 days.

Possibilities of producing soft drink from sweet cheese whey using different types of stabilizers and fruit concentrates (Orange, Mandarin, lemon and apple), were investigated by (Niketic and Marinkovic, 1984). Drinks made from acid whey with 2-4% orange juice concentrate possessed the best organoleptic quality. They were produced on sterilization line with heat treatment at 95°C/5 seconds followed by homogenization and packaging.

Reddy *et al.* (1987) developed an acceptable beverage containing deproteinized cheddar cheese whey, 8% lemon juice and 14% sugar. The shelf life of the product was up to 15 days at room temperature (18-25°C) without much damage to the organoleptic quality.

Tuohy *et al.* (1988) reported that acid whey was most suitable for blending with fruit juices to produce cloudy, fruit drinks. A pH of less than 4 was recommended to prevent protein coagulation during pasteurization. The pH reduction was achieved by addition of lactic or other organic acids. The pectin esterase was inactivated at 85-95°C/15-40 seconds to prevent loss of cloudiness, which is required in fruit juices. The product had shelf life of 2 weeks at refrigeration temperature. A combination of blanched soybean cotyledons and lactose-reduced condensed whey, with 7% sugar, and 0.7 g/kg strawberry flavours gave an acceptable beverage. Successful spray drying of the beverage was achieved at 190°C inlet air temperature and 92°C outlet air temperature. The sugar was dry blended with the powder (Patil & Gupta, 1982).

Mandal *et al.* (1997) developed a formulation for beverage from fresh chhana whey (deproteinized) by the addition of 1.5 ml citric acid, 3 ml lemon juice and 10% sugar to 100 ml of diluted deproteinized whey. Dhandayuthapani *et al.* (1997) developed an enriched whey beverage by mixing deproteinized chhana whey with 8% lemon juice, 14% sugar and 0.5% sodium bicarbonate and heating at 80°C for 15 min. Vitamin-A was then added @ 1000 IU/100 ml before bottling in amber coloured bottles. The fortified whey beverage could be stored for 15 days at room temperature without loss of quality.

Meduzov *et al.* (1990) reported a method of manufacture of a protein beverage by using whey, fruit syrup. pectin (0.4-0.8% by weight of end product), pasteurizing and packaging of product. Iniguez and Vera (1999) developed a formulation for flavoured beverage using buffalo milk whey, concentrated pineapple juice (4.0 to 5.0%) or concentrated orange juice (4.5-5.0%). Shelf life of the beverage was 7-8 days at 4°C.

Chem, Bassette and Marchal (1979) formulated an imitation milk (2.4% protein) by combining four parts of neutralized direct acid set cottage cheese whey with 6% of whole milk and fortifying it with 0.5% dried skim milk.

Krishanaiah, *et al.*, (1989) developed an acceptable beverage with good organoleptic qualities from acid whey by mixing 3 parts of acid whey, one part toned milk, 10% sugar, pineapple essence and yellow colour. The pH of the beverage was 6.8.

2.5.3. FERMENTED BEVERAGES FROM WHEY

From time immemorial the people in various parts of the world have been producing and consuming various fermented milk products. These products are particularly popular among children and aged people. The therapeutic and dietetic properties of fermented milks have been attracting the human population since ages and the popularity of these products is gaining momentum at an accelerated rate.

Among various fermented milk products dahi is well known in India and has been in use since distant past it was as popular as it is today even in the days of Vedic culture. Lassi (cultured drink), one of the product made from dahi, is very common in the tropical countries. However, in rural areas, the term "lassi" is generally used for a by-product of deshi butter (used for ghee making) obtained by churning of dahi which is called "kacchi lassi". It is the most common in the diet of rural population.

In urban areas lassi is made exclusively from dahi. Lassi is not only refreshing and delicious but is also nutritious, and easily digestive which makes it quite popular amongst all age groups. Unfortunately, the high cost of this product and the short supply of raw material required for its manufacture i.e. milk,

make it beyond the reach of majority of the Indian population, particularly to those belonging to lower income group. It will, therefore, be a better option to use the whey solids along with milk to develop a lassi-like product and hence the literature related to lassi-like product is reviewed here under:

Besserzhnov (1968) patented a method for manufacture of a whey beverage which involved pasteurization of cheese whey at 72°C with 20 seconds holding, cooling to 45°C, inoculation with 10% culture consisting of *L. bulgaricus, L.acidophilus, L.helveticus, L.casei, and S.thermeophilus* and incubation at 42-45°C for 18-24hrs until it attained titratable acidity of 170°-200°T followed by cooling of product to 8-10°C and packaging.

Peer (1970) reported a method for manufacture of cultured whey product with 0.2-0.4% acidity and pH 6.0-6.6 containing 5-7 percent whey solids and 2-4% sugar. The whey was treated with calcium carbonate($CaC0_3$) and diammonium phosphate followed by inoculation with *L.acidophilus* and incubation at 100°F until pH of 3.8-4.0 was attained.

Schwab (1994) used whey in sweet fermented and acidified soft drinks. Sweet whey beverage was formulated using decreamed whey, sugar (7%) and pectin with optional flavours such as banana. Fermented beverages are produced by fermentation of pasteurized whey with a yoghurt culture and subsequent addition of sufficient food grade acid (lactic acid) followed by addition of sugar, pectin and fruit flavouring.

Knee and Hong (1993) developed ginseng-whey beverages from rennet whey, Ginseng extract (0.2%), sweetener (1.0%), honey (0.5%) Japanese apricot extract (0.2%). The mixture was inoculated with mixtures of lactic acid bacteria (1%), packaged and stored at 30 ± 1°C.

Pijanowski *et al.* (1974) used kefir grains for the fermentation of whey at 25°C for 5 hrs. Grinene (1977) patented a method for manufacture of fermented beverage containing whey, sugar and flavouring substances. The mixture was cooled, inoculated with a mixture of *S. cremoris* and *S. diacetylactis* (1.0-1.2% by weight of whey), incubated at 40-42°T and then cooled to 24-25°C. Wroblewska (1977) developed whey beverage from a mixture of 2% fat milk, rennet whey of 4.5-7.0°SH titratable acidity, salt (10g/litre) and vegetable & fruit extracts. The mixture was fermented using *steptococci/lactobacilli* starter. Marhounova (1980) reported a method for manufacture of thermized (heat treated) beverage from milk and whey. A mixture of whey (82%) with 5-10% whey suspension of Frimbioin WB stabilizer was heated to 75°C, cooled to 45°C and incubated to pH 3.8 with 5% Yogurt culture to prepare a whey beverage.

Khrulkevich (1959) prepared a beverage from whey and buttermilk. The method of preparation involved mixing equal volumes of whey and buttermilk and addition of a culture of Koumiss yeasts. The beverage resembled Koumiss and had a refreshing sour alcoholic taste.

It is clear form the preceding review of literature that economic utilization of whey is still a real challenge for the dairy industry despite numerous reports claiming to have over come it. Several reports indicate the possibility of utilizing cheddar cheese whey as a base for whey-milk beverages. However, such whey based beverages because of limited shelf life need to undergo significant improvements with respect to storage stability and acceptability. Attempts made in the direction of producing long-shelf life whey-milk beverage have shown a great potential. Therefore there is tremendous scope for a systematic approach to develop whey-milk beverage utilizing cheese whey

and buffalo milk. Formulation of such product holds great promise to enable economic utilization of whey and value addition to guarantee high income.

For development of cultured whey based product which is a low cost yet nutritious and as delicious product as conventional lassi making use of cheese whey and milk also has a great promise. Also looking at the Indian dietary habit where a cultured product is almost an inevitable one, such a low-cost CWMB is expected to go a long way to contribute to the much publicized slogan of "plenty and prosperity". A product of this type is expected to have a big commercial potential with economic utility and practical applicability owing to its simple technology of manufacture which can be easily adopted by small enterprises with minimum equipment and capital investment.

Thus these products are expected to provide soft drink and moreover they will provide a profitable outlet of hitherto getting wasted.

CHAPTER-3

MATERIALS & METHODS

3. MATERIALS AND METHODS

This chapter deals with various materials and methodologies relating to the technological, analytical, and statistical aspects employed during the present investigation.

3.1. MATERIALS

3.1.1. Cheese Whey

Whey used in the present investigation was obtained from the Experimental Dairy Plant, National Dairy Research Institute, Karnal as a by-product of cow milk Cheddar cheese manufactured by adopting the method of Kosikowski (1982) with slight modification.

3.1.2. Paneer Whey

Paneer whey was obtained during the manufacture of buffalo milk paneer from the Experimental Dairy Plant, National Dairy Research Institute, Karnal.

3.1.3. Sugar

Commercially available cane-sugar (Grade-C) procured from the local market of Karnal was used as sweetener agent.

3.1.4. Stabilizer

Guar gum, supplied by Hindustan Gum and Chemicals Ltd. Bhiwani (Haryana), was used for whey-milk beverage

(WMB) and CMC (Carboxy methyl cellulose) supplied by M/s LOBA CHEMICAL, BOMBAY was used for cultured whey-milk beverage (CWMB).

3.1.5. Dahi Culture of CWMB

For CWMB lactic culture NCDC–167, multiple mixed culture was procured from the NCDC, Dairy Microbiology Division, National Dairy Research Institute, Karnal.

3.1.6. Milk

Buffalo milk, skim milk and cream were obtained from the Market Milk Section, Experimental Dairy Plant, National Dairy Research Institute, Karnal.

3.1.7. Flavour

Food grade strawberry essence and rose essence supplied by BUSH BOAKE ALLEN (INDIA) LTD., Chennai were used.

3.1.8. Colour

Food grade raspberry red colour powder procured from BUSH BOAKE ALLEN (INDIA) LTD., Chennai was used.

3.1.9. Chemicals

All chemicals used in the investigation were of AR grade.

3.1.10. Packaging material

Polyethylene film was used for the packaging of WMB and CWMB. Food grade, co-extruded-multilayered, LDPE (Low density polyethylene) film of white colour was used. Its thickness was 60 microns.

3.2. METHODS

3.2.1. Plan of work

3.2.1.1 **Standardisation of the process for the manufacture of whey-milk beverage (WMB):**

- **Effect of type of whey for WMB.**
  - Cheese whey & paneer whey
- **Selection of cheese whey level for whey-milk beverage (WMB).**
  - 60, 70, 80 & 90%
- **Selection of stabilizer level for WMB.**
  - 0, 0.025, 0.05, 0.075 & 0.1%
- **Selection of Paneer whey level for WMB**
  - 50, 60 & 70%.
- **Selection of type of whey for cultured WMB.**
  - Cheese whey & paneer whey
- **Selection of whey level for cultured WMB.**
  - 60, 70 & 80%
- **Selection of stabilizer for cultured WMB.**
  - Carboxy methyl cellulose(CMC), Guar-gum & Pectin

3.2.2. Formulation of whey milk beverage

Cheddar cheese whey was obtained and analysed for fat, pH, acidity, lactose and protein. Then it was heated to 72°C to inactivate the residual coagulating enzyme (rennet). For utilization of paneer whey for manufacture of WMB, the paneer whey was neutralized to an acidity of

0.14% LA using sodium hydroxide(NaOH) . Buffalo milk was then standardized for fat to get a final fat percentage of 2% in WMB. Thereafter, the standardized milk and processed whey were mixed. Stabilizer and sugar were dry blended and then added to the mixture of whey and milk followed by filtration, homogenization and pasteurization (72°C/15 sec). Colour and flavour addition was done at 4°C followed by packaging and storage.

The process flow diagrams for the manufacture of cheese whey-milk beverage and paneer whey-milk beverage are shown in Fig.3.2 and 3.3 respectively.

3.2.3. Formulation of cultured whey milk beverage

Cheese whey was heated to 72°C and buffalo milk was standardized to get a final fat level of 3.1 percent in the final product. Treated whey and standardized milk were then mixed with the addition of sugar and stabilizer (CMC 0.3 percent) followed by filtration and heating to 80-90°C/15-30min. Then it was cooled to 30°C for inoculation with lactic culture @ 1.0% and incubated at 30°C for 14-16 hrs. After incubation, homogenization of fermented whey milk was done followed by cooling to 4°C, addition of flavour and finally packaged and stored at 4±1°C.

The process flow diagrams for the manufacture of cultured whey-milk beverage are shown in Fig.3.4.

3.3. SENSORY EVALUATION

The products so obtained were subjected to sensory evaluation to select the best combination of different ingredients. A selected panel of 5-7 judges evaluated the sensory attributes (flavour, consistency, colour & appearance and overall acceptability) of the products. The

FIG. 3.2. PROCESS FLOW DIAGRAM FOR CHEESE WHEY-MILK BEVERAGE

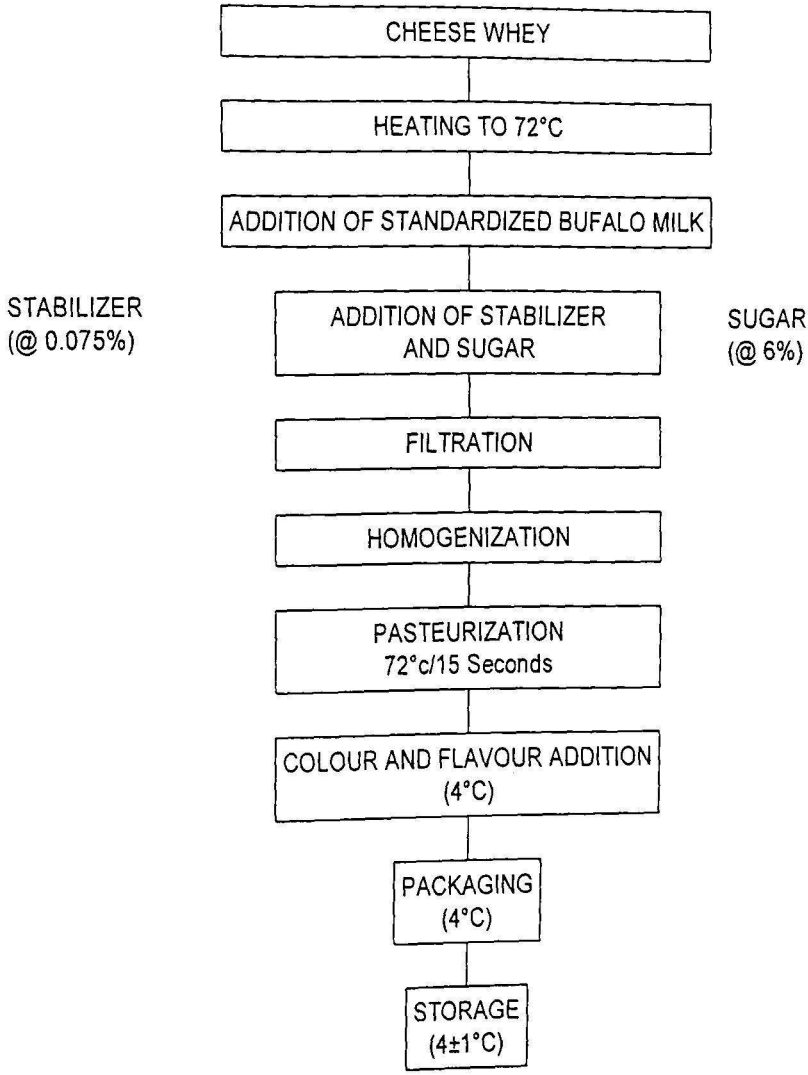


FIG. 3.3. PROCESS FLOW DIAGRAM FOR PANEER WHEY-MILK BEVERAGE

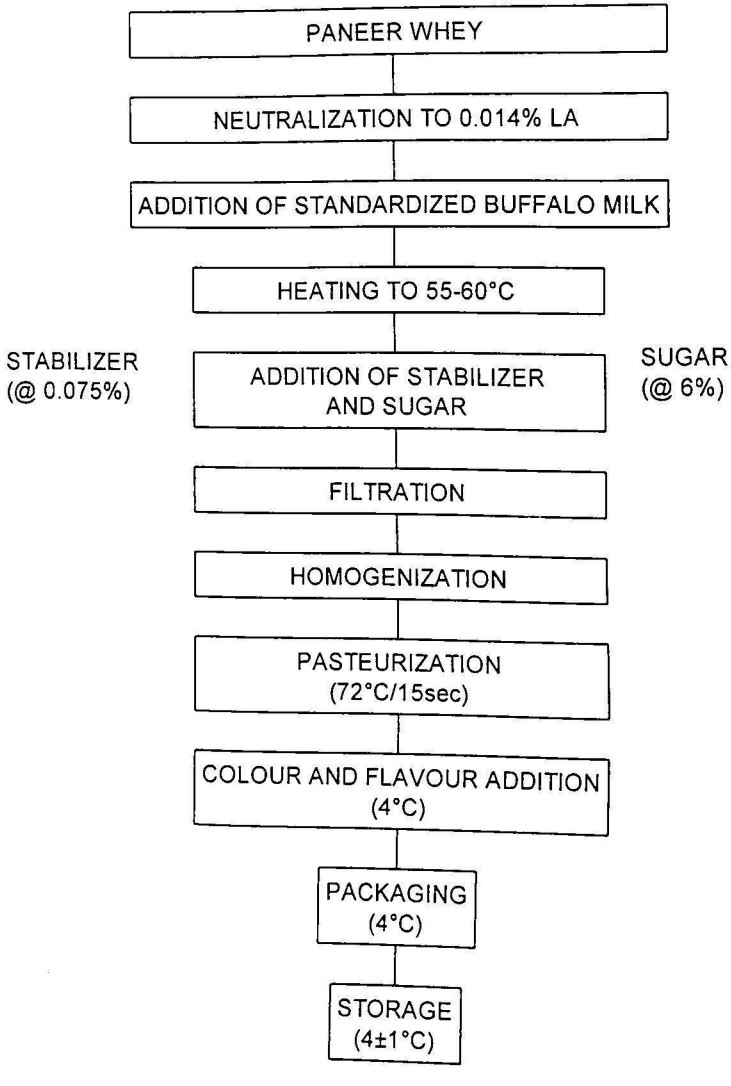
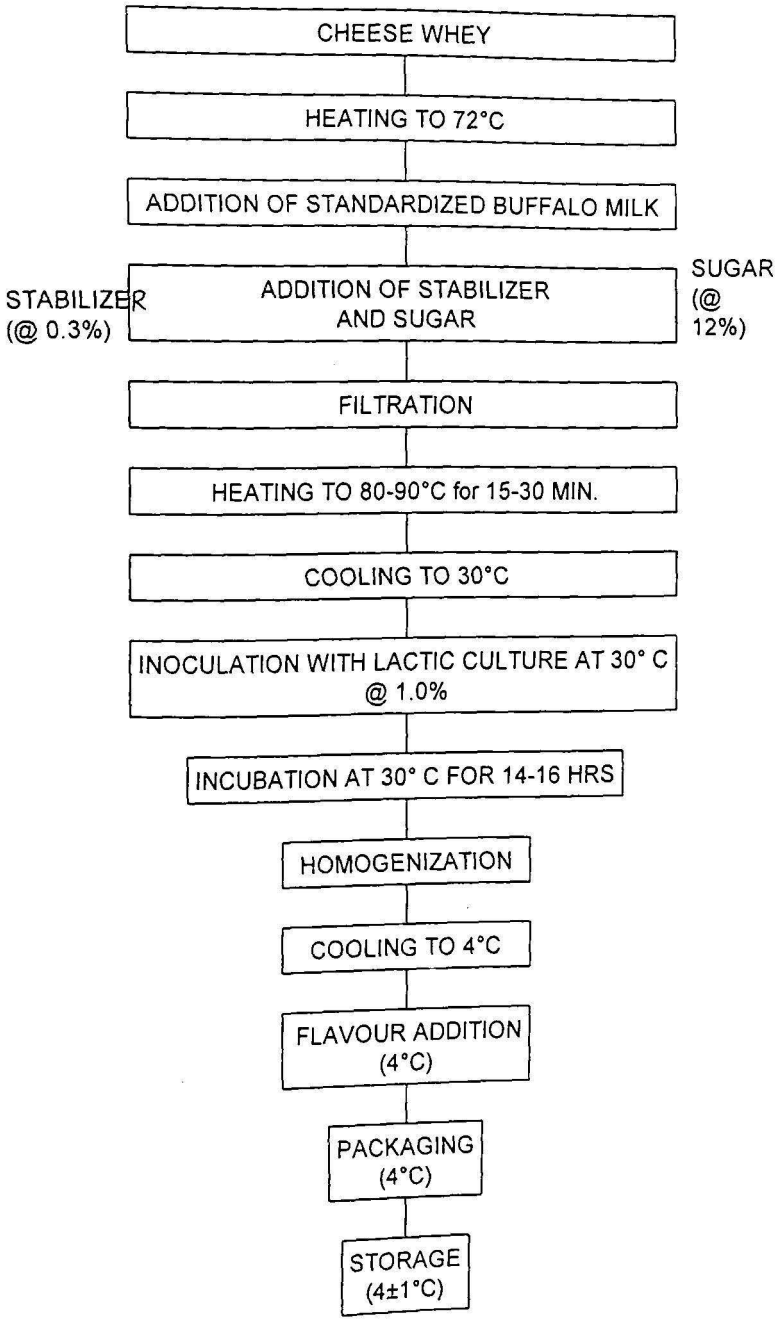


FIG. 3.4. PROCESS FLOW DIAGRAM FOR CULTURED WHEY-MILK BEVERAGE



evaluation of the products carried out on a 9 point Hedonic scale (Appendix-IX).

3.4. CONSUMER RESPONSE STUDY

Pasteurized WMB was served to the individuals included in the study for the consumer rating for the developed product. These individuals, randomly selected from among the staff of the institute, represented nearly a cross section of the society. Their response was recorded in the Performa as given in APPENDIX-VIII.

3.5. STORAGE STUDY

WMB & CWMB were stored at refrigerated temperature (4±1°C) and were analyzed for changes in acidity and sensory attributes at the interval of three days.

3.6. ANALYTICAL METHODS

3.6.1.Physico-Chemical Analysis

Milk and whey were analysed for physico-chemical properties as per the methods delineated below:

3.6.1.1.Whey and Milk

3.6.1.1.1. Total solids

Total solids content of whey was determined using Gravimetric method as per IS : 1479 : Part-I (1961).

3.6.1.1.2. Fat

Fat content was estimated by Gerber method using skim milk Butyrometer as per IS : SP : Part-XI (1981).

3.6.1.1.3. Lactose

Lactose content was determined by Lane Eynon method as described in IS : SP : Part-XI (1981).

3.6.1.1.4. Titratable Acidity

Acidity was measured by titrating 10 g of sample against 0.1N NaOH using phenolphthalein indicator, and expressed in terms of % lactic acid as per the method described in IS : 1479 : Part-I (1962).

3.6.1.1.5. Absolute viscosity

Absolute viscosity was estimated by the method as described in Laboratory Manual of Dairy Chemistry by Dairy Education Board (1969), India.

3.6.1.1.6. pH

The pH was measured by a microprocessor based pH-meter (Labindia Instruments Pvt. Ltd., Mumbai) fitted with a orion gel-filled combined electrode.

3.6.1.1.7. Total Protein

Total Nitrogen content was estimated by standard AOAC method (1995). From the total nitrogen total protein was obtained by multiplying with a factor 6.38.

3.6.1.2. WMB AND CWMB

3.6.1.2.1. Total solids

As described in 3.6.1.1.1.

3.6.1.2.2. Fat

As described in 3.6.1.1.2.

3.6.1.2.3. Lactose

As described in 3.6.1.1.3.

3.6.1.2.4. Titratable Acidity

As described in 3.6.1.1.4

3.6.1.2.5. Absolute viscosity

As described in 3.6.1.1.5

3.6.1.2.6. pH

As described in 3.6.1.1.6

3.6.1.2.7. Total Protein

As described in 3.6.1.1.7

3.7. STATISTICAL ANALYSIS

Data obtained from the various experiments during standardization process and storage studies were analysed statistically as described by (Snedecor and Cochran (1994).

3.8. COST ESTIMATION

The cost of manufacture of WMB and CWMB was estimated as per the case study of Singh and Kalra (1975) with some modifications. In order to arrive at a realistic cost of processing and that of the final product, certain assumptions were made. It was assumed that the product would be manufactured by the dairy, producing cheese alongwith other products like market milk etc. so that the available quantity of whey could be utilized.

CHAPTER-4

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

This study was undertaken to explore the possibility of whey, the by-product of cheese/paneer industry - for the manufacture of whey-milk beverages. The main aim was to utilize maximum quantity of whey in the product without compromising with the quality and acceptability of the product.

Suitable combinations of cheddar cheese whey and paneer whey with milk were evolved for the manufacture of delicious, nutritious and thirst quenching whey-milk beverages. The products were examined for sensory and physico-chemical characteristics, and for its shelf life. The results obtained during standardization of the manufacturing process of whey-milk beverages and cultured whey – milk beverage and their storage are presented in this chapter.

4.1. PHYISCO-CHEMICAL ATTRIBUTES OF RAW MATERIALS FOR THE MANUFACTURE OF WHEY – MILK BEVERAGES

4.1.1. CHEMICAL COMPOSITION OF CHEESE WHEY, PANEER WHEY AND BUFFALO MILK

The chemical composition of cheese whey and paneer whey are presented in table 4.1. Cheese whey contained more total solids (6.3%), protein (0.9%) and fat (0.3%) than that of paneer whey (6.0%, 0.3 and 0.13% respectively). Paneer whey contained higher lactose (5.03 %) and acidity (0.23 %LA) than those of cheese whey (4.9 and 0.17 % LA respectively). Khamrui (2000) and Jayaprakash (1986) also reported similar values for fat, lactose and protein contents of whey. The pH values were 6.2 for cheese whey and 5.6 for paneer whey.

Buffalo milk used in the study contained on an average 6.8%fat, 3.8% protein and 5.1% lactose.

4.1.2. PROCESS STANDARDIZATION FOR WHEY-MILK BEVERAGE (WMB) AND CULTURED WHEY-MILK BEVERAGE (CWMB)

4.1.2.1. Effect of type of whey on sensory quality of WMB

Two types of whey, were used for the manufacture of WMB. The sensory score if the products is shown in table-4.2.

It was observed that the cheese whey yielded WMB, which scored maximum for flavour, consistency, colour and appearance and overall acceptability than that made from paneer whey. This could be attributed to the use of neutralizer (NaOH) for reducing the titratable acidity of paneer whey and its low total solid contents. Since the titratable acidity of paneer whey was higher it required neutralization before mixing with the milk and the use of neutralizer left its after taste. Also the consistency of the product was thin because of the low total solids in the whey.

Analysis of variance of the results showed significant effect of cheese whey and paneer whey on the flavour and overall acceptability at ($P<0.01$) and ($p<0.05$) (APPENDIX -I).

4.1.2.2. Effect of levels of cheese whey on sensory quality of WMB

WMB was manufactured by using buffalo milk and different levels of whey (60, 70, 80 and 90 %) following the method of manufacture as shown in Fig.3.2 for WMB and the effect on sensory quality of the product is presented in table-4.3. The results revealed that the product in which 60 percent whey was used received the maximum sensory score while that made with 70, 80 and 90 % received lower sensory score. The consistency score of the product was however minimum for the product made with 90 % whey.

Analysis of variance of the data, however, revealed significant effect ($P<0.05$) of whey levels on sensory quality of WMB.

Table 4.1. CHEMICAL COMPOSTION OF BUFFALO MILK, PANEER WHEY AND CHEESE WHEY

Raw Material	COMPONENTS				
	T.S.(%)	Fat(%)	Protein(%)	Lactose(%)	Acidity(%LA)
Buffalo milk	16.5	6.8	3.8	5.1	0.14
Paneer whey	6.0	0.1	0.3	5.0	0.23
Cheese whey	6.8	0.3	0.9	4.9	0.14

TABLE 4.2. EFFECT OF TYPE OF WHEY ON SENSORY QUALITY OF WHEY-MILK BEVERAGE

TYPE OF WHEY	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
CHEESE	7.5	7.8	7.6	7.8
PANEER	7.3	7.6	7.5	7.6

TABLE 4.3. EFFECT OF VARIOUS LEVELSOF CHEESE WHEY ON SENSORY QUALITY OF WHEY-MILK BEVERAGE

LEVEL OF WHEY (%)	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
60	7.5	7.5	7.5	7.5
70	7.4	7.4	7.5	7.4
80	7.4	7.4	7.4	7.4
90	7.4	7.2	7.4	7.4

Although , there was a significant effect of whey levels (P<0.05) on the consistency of WMB as shown in APPENDIX-II the product made with 80 percent whey was found to be equally acceptable as those made with lower levels of whey. Hence it was selected for subsequent experiments.

4.1.2.3. Effect of stabilizer level on sensory quality of WMB

Stabilizers are known to improve the consistency and stability of food system. Kriel and Van Tonder (1979) recommended the use of guar gum for manufacture of whey-milk chocolate drink. Different levels of guar gum were therefore used to improve the consistency of WMB. Four different levels of stabilizer (0.025, 0.05, 0.075 and 0.1%) were added to WMB and the effect on sensory quality of the product studied. The sensory data obtained is summarized in table 4.4.

It was observed that WMB made with the addition 0.075% and 0.1% stabilizer levels resulted in a product, which received maximum sensory score for consistency and overall acceptability. The flavour score for 0.1 percent stabilizer level was however lower than that for 0.075%. Hence 0.075% level of stabilizer was considered the most desirable.

Analysis of variance of the data on the effect of different stabilizer levels (0.025, 0.05, 0.075 and 0.1 %) on sensory scores of WMB showed significant effect ($p< 0.01$) on consistency and overall acceptability (APPENDIX-III).

4.1.2.4. Effect of level of paneer whey on sensory quality of WMB

After ascertaining the acceptability of WMB made with cheese whey it was considered desirable to study the effect of different levels of paneer whey on sensory quality and its acceptability. Therefore,

paneer whey was admixed after neutralization with the milk at three different levels and the WMB was prepared.

The use of paneer whey in the manufacture of WMB yielded a product with thin consistency and lower flavour score due to neutralizer after taste and lower total solids. The consistency of the product made from cheese whey could be improved by the use of guar gum at 0.075% level. It was, therefore, considered desirable to use guar gum at 0.075% level and prepare WMB using reduced proportion of paneer whey and increasing the proportion of milk for improving the consistency and flavour.

Sensory scores of WMB prepared with different levels of paneer whey (50,60 and 70 percent) are given in Table-4.5. The sensory scores of the products made with 60 and 70 percent whey levels were similar but slightly lower than that of the product made with 50 percent whey level. However, the product was acceptable up to 70 percent admixing of whey with milk. Hence this level was selected in case WMB was to be made using neutralized paneer whey.

Analysis of variance did not show any significant effect of admixing different levels of paneer whey on the sensory attributes of the WMB suggesting that all the whey levels performed equally good in the product (APPENDIX-IV).

4.1.2.5. Effect of type of whey on sensory quality of cultured WMB

Cultured WMB was prepared separately by admixing 80% of the cheddar cheese whey and paneer whey with 20% and 30% respectively of standardized buffalo milk. The sensory score received by the products is given in Table-4.6. It was observed from the Table. that sensory score of cultured WMB prepared from the cheese whey was slightly higher than that made with paneer whey. The flavour, consistency, colour and appearance score as well as overall

TABLE 4.4. EFFECT OF LEVEL OF STABILIZER ON SENSORY QUALITY OF WHEY-MILK BEVERAGE

LEVEL OF STABILIZER (%)	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
NO STAB.	7.2	7.2	7.1	6.9
0.025	7.2	7.3	7.2	7.1
0.05	7.2	7.5	7.2	7.2
0.075	7.2	7.6	7.2	7.4
0.1	7.1	7.6	7.2	7.4
CONTROL	7.3	7.7	7.3	7.5

TABLE 4.5. EFFECT OF DIFFERENT PROPORTIONS OF PANEER WHEY ON SENSORY QUALITY OF WHEY-MILK BEVERAGE

WHEY LEVEL (%)	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
70	7.5	7.4	7.6	7.5
60	7.5	7.4	7.6	7.5
50	7.6	7.5	7.7	7.6

acceptability score of the cultured WMB made from paneer whey was lower. The consistency of CWMB prepared from cheese whey was also criticized for thin consistency. Hence only cheese whey was used in the formulation for preparation of cultured WMB.

Analysis of variance of the data also revealed that the two types of whey had no significant effect on the sensory attributes of product. However, the judges preferred only cheese WMB (APPENDIX-V).

4.1.2.6. Effect of cheese whey level in cultured WMB

To the study the effect of lower levels of cheese whey on the consistency of CWMB batches were prepared using different levels of cheese whey.

The organoleptic quality of cultured WMB made with different levels of cheese whey was evaluated and the data is presented in Table-4.7. Three different levels of whey (60, 70 and 80 percent) were added to milk standardized to 9.64% fat and cultured WMB prepared. It was observed that the sensory score of cultured WMB decreased marginally with the increase in proportion of cheese whey in the product, however, the acceptability of the products made with 60 and 70 percent cheese whey was the same hence 70 percent level was considered desirable in the formulation for further studies.

Analysis of variance of the sensory data obtained showed that different levels of cheese whey had no significant effect on the sensory attributes of the product (APPENDIX-VI).

4.1.2.7. Selection of type of stabilizer for cultured WMB

In order to improve consistency of the product three different stabilizers (Carboxymethyl cellulose(CMC), Guar gum and pectin)

were added to the cultured WMB at 0.3 percent level suggested by Ramana (1994) and the most suitable was one selected.

The sensory score on the quality of cultured WMB is presented in Table-4.8. It was observed from the result that the sensory score of cultured WMB was maximum for the product which was made using CMC as compared to the products in which guar gum or pectin was used as stabilizer. The flavour and consistency scores were minimum in case of cultured WMB in which pectin was used. The product made using CMC was considered to be the most acceptable as compared to the other two products.

Analysis of variance also showed significant effect of the type of stabilizer on the overall acceptability of the product (APPENDIX-VII).

The composition of the final products (whey-milk beverages and cultured whey-milk beverage) is shown in Figures 4.7, 4.8 and 4.9.

4.1.3. CONSUMER RESPONSE STUDY

Consumer response data for paneer WMB depicted in Fig.-4.5, depicts that 48 percent of the consumers liked it very much while 23 percent liked it moderately. The consumer response study of the cheese WMB as shown in Fig.-4.6 revealed that 55 percent of the consumers liked the it much and 32 percent liked it moderately. The acceptability of cheese WMB was higher among the consumers. However, some of the consumers felt that the addition of skim milk powder to the product could improve its consistency and the mouth feel without adversely affecting the flavour of the beverage.

4.1.4. CHANGES IN ACIDITY AND SENSORY ATTRIBUTES DURING STORAGE OF WMB

4.1.4.1. Changes in acidity

Changes in the titrable acidity of the cheese WMB, paneer WMB and cultured WMB is given in table-4.9. As expected the titratable acidity of the products increased with the storage time. The

Fig. 4.5. CONSUMER ACCEPTANCE OF PANEER WHEY-MILK BEVERAGE

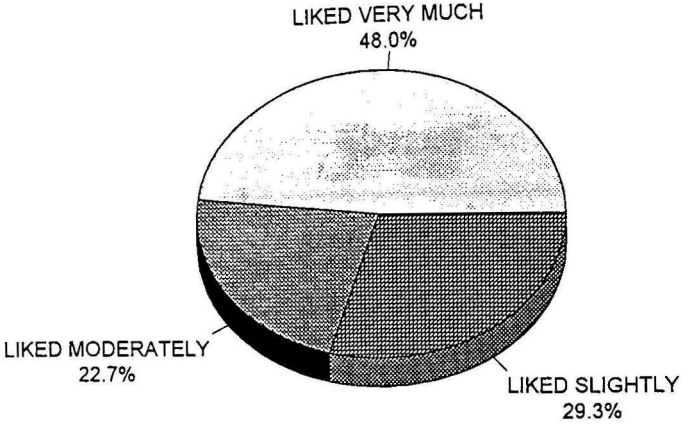


FIG. 4.6. CONSUMER ACCEPTANCE FOR CHEESE WHEY-MILK BEVERAGE

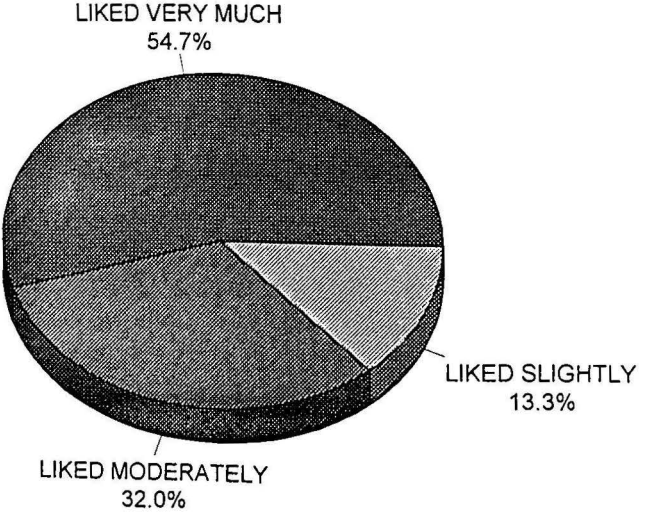


TABLE 4.6. EFFECT OF TYPE OF WHEY ON SENSORY QUALITY OF CULTURED WHEY-MILK BEVERAGE

TYPE OF WHEY	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
CHEESE	6.8	6.9	7.1	7.1
PANEER	6.7	6.7	7.0	6.9

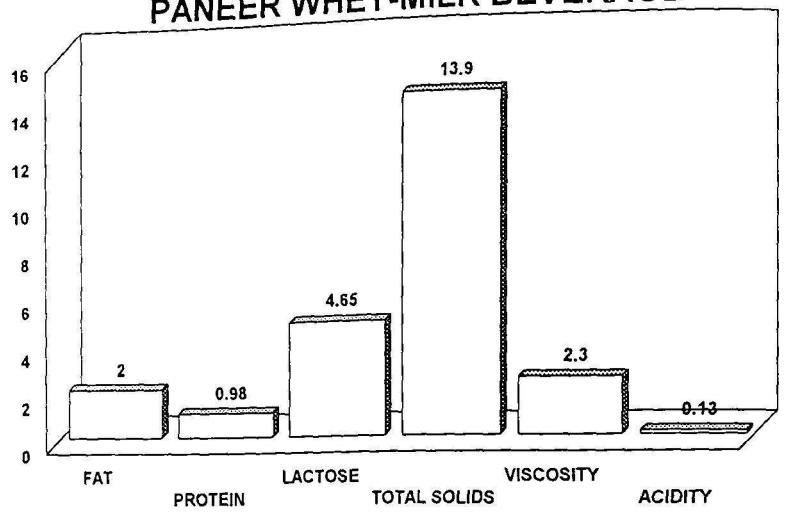
Table 4.7. EFFECT OF DIFFERENT PROPORTIONS OF CHEESE WHEY ON SENSORY QUALITY OF CULTURED WHEY MILK BEVERAGE

LEVEL OF WHEY(%)	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
80	6.6	6.7	6.9	6.2
70	6.7	6.8	6.9	6.6
60	6.7	6.8	7.0	6.6

TABLE 4.8. EFFECT OF TYPE OF STABILIZER ON SENSORY QUALITY OF CULTURED WMB

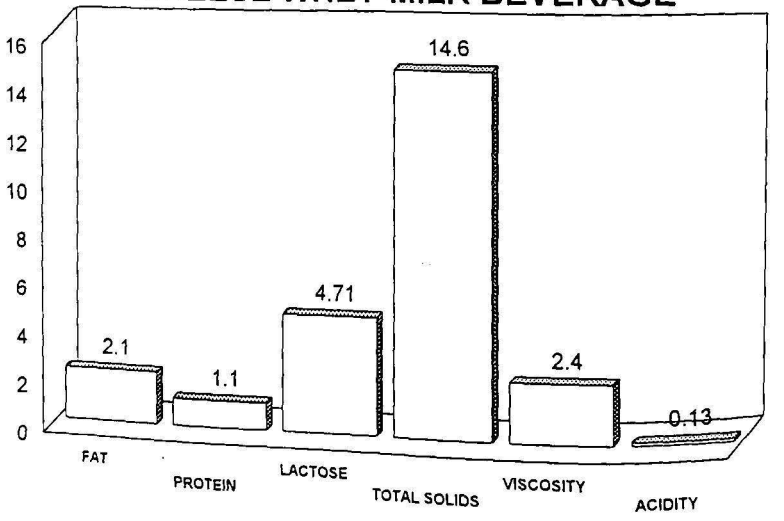
TYPE OF STABILIZER	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
CMC	6.8	7.2	7.0	6.8
GUAR GUM	6.5	6.8	7.0	6.6
PECTIN	6.3	6.6	7.0	6.3

Fig. 4.7. PHYSICO-CHEMICAL COMPOSITION OF PANEER WHEY-MILK BEVERAGE



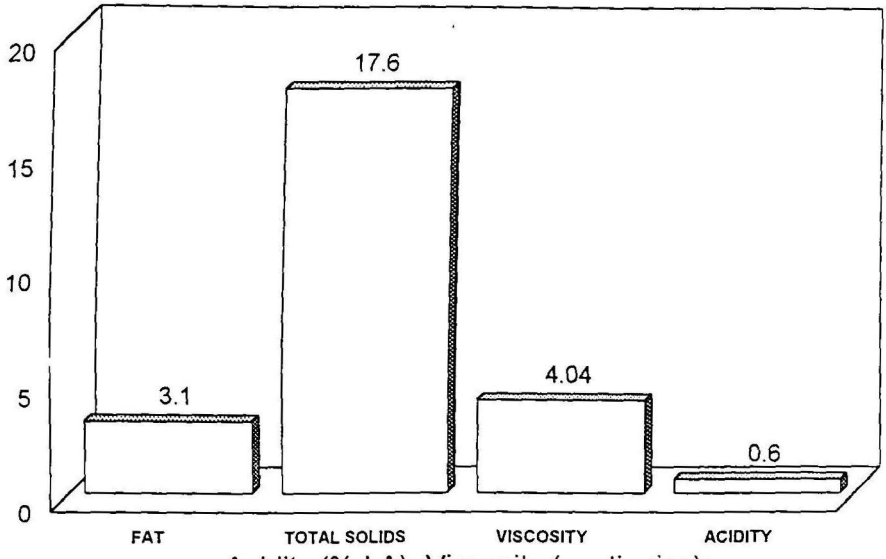
Acidity (% LA), Viscosity (centipoise);

Fig. 4.8. PHYSICO-CHEMICAL COMPOSITION OF CHEESE WHEY-MILK BEVERAGE



Acidity (% LA), Viscosity (centipoise);

Fig. 4.9. PHYSICO-CHEMICAL COMPOSITION OF CULTURED WHEY-MILK BEVERAGE



Acidity (% LA), Viscosity (centipoise);

Table 4.9. CHANGES IN ACIDITY OF WMB AND CWMB DURING STORAGE

Time Interval	ACIDITY (% LA)		
	WMB*	WMB**	Cultured WMB
0-DAY	0.13	0.13	0.58
3-DAY	0.14	0.14	0.62
6-DAY	0.14	0.15	0.64
9-DAY	0.15	Unacceptable	-

* Paneer whey-milk beverage

** Cheese whey-milk beverage

combined effect of the activity of the residual enzyme and the acidity of cheese WMB and cultured WMB after 7-days was enough for making the product unacceptable. However, the acidity of paneer WMB did not develop to the extent to make the product unacceptable up to 9-days of storage.

4.1.4.2. Changes in sensory score during storage of WMB

The changes in sensory score of WMB and CWMB during storage are given in table-4.10, 4.11 and 4.12. The flavour score of the stored cheese WMB samples (at 4±1°C)decreased during storage . The decrease in flavour score was maximum for cheese WMB (from 7.5 to 6.8) as compared to paneer WMB (from 8 to 7) and cultured WMB (from 7.3 to 6.8). Also, after 7-days of storage the cheese WMB become unacceptable. However, paneer WMB remained acceptable at the refrigerated storage temperature even after 9-days. Khamrui (2000) also reported decrease in flavour during the storage of whey based kinnow juice concentrate/powder. Cultured WMB also showed decrease in flavour score during storage because of development of sharp acidic flavour.

Consistency score of the WMB did not change markedly for cheese WMB and cultured WMB. However, the consistency score of the WMB prepared from paneer whey decreased during storage.

Colour and appearance score for the cheese WMB and paneer WMB decreased with storage period. This might be attributed to the fact that with the increase in acidity discoloration of product occurred . On the other hand colour and appearance score of the cultured WMB did not decrease much.

Overall acceptability score followed a similar trend as that of flavour score of WMB. The changes in flavour affected the overall acceptability of the product. The overall acceptability of cultured WMB

was adversely affected due to the development of sharp acidic flavour during storage.

4.1.5. COST APPRAISAL

The production cost of WMB and CWMB was calculated using the procedure as outlined by Singh and Kalra (1975). The cost of production was estimated by taking following assumptions:

i) the products would be manufactured by the dairies who have already the processing facilities such as cream separator, storage tanks etc.

ii) Handling loss- 2%

iii) The cost of raw materials and labour charges were taken as per the current market price.

iv) The cost of 200 ml pouch of WMB and CWMB was calculated as Rs.1.67 and Rs.2.74 respectively. The cost analysis is given in Table-4.13 and Table-4.14.

TABLE 4.10. STORAGE STUDY OF CHEESE WHEY-MILK BEVERAGE

DAYS INTERVAL	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
0-DAY	**7.5**	7.6	7.9	7.9
3-DAY	7.3	7.5	7.8	7.3
6-DAY	6.8	7.5	7.7	6.8

TABLE 4.11. STORAGE STUDY OF PANEER WHEY MILK BEVERAGE

DAYS INTERVAL	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
0-DAY	8	8	7.9	8.2
3-DAY	7.5	7.8	7.8	7.8
6-DAY	7.3	7.7	7.8	7.2
9-DAY	7	7.7	7.7	6.6

TABLE 4.12. STORAGE STUDY OF CULTURED WHEY-MILK BEVERAGE

DAYS INTERVAL	FLAVOUR	CONSISTENCY	COLOUR & APPEARANCE	OVERALL ACCEPTABILITY
0-DAY	**7.3**	7.1	7.0	7.0
3-DAY	7.0	7.0	6.9	6.8
6-DAY	6.8	7.0	6.9	6.7

TABLE 4.13 COST OF PRODUCTION OF 1000 LITRE OF CULTURED WHEY-MILK BEVERAGE

Sl. No.	Item	Qty	Rate	Amount (Rs)
Variable cost				
1	**Buffalo milk** Fat 9.64% SNF 8.5%	300lt 28.92kg 25.5 kg	 Fat Rs. 109.2/kg SNF Rs.72.8/kg	 3155.88 1856.40
2	Sugar	120 kg	Rs. 16/kg	1920.00
3	Culture (1.0%)	10 kg	Rs. 200/kg	2000.00
4	Flavour (strawberry) (0.025%)	250ml	Rs. 200/500ml	100.00
5	Stabilizer (0.3%)	3 kg	Rs. 250/kg	750.00
6	Processing cost	-	Re. 1/litre	1000.00
7	Packaging material	15 kg	Rs. 93/kg	1395.00
8	Whey	700 lit	-	-
Sub total (A)				13177.20
Fixed cost				
1.	Labour Supervisor	1	Rs. 500/day	500.00
2	Plant Operator	1	Rs. 350/day	350.00
3	Attendent	2	Rs. 200/day	400.00
Sub Total (B)				1250.00
Cost of Production (A+B)				13427.20
	COST/POUCH			2.74

TABLE 4.14. COST OF PRODUCTION OF 1000 LITRE OF WHEY-MILK BEVERAGE

Sl. No.	Item	Qty	Rate	Amount (Rs)
Variable cost				
1	Buffalo milk Fat 8.8% SNF 8.4%	200lt 17.6kg 16.8 kg	 Fat Rs. 109.2/kg SNF Rs.72.8/kg	 1921.92 1223.04
2	Sugar	60 kg	Rs. 16/kg	960.00
3	Colour @ (1.5g/40lit)	27.5 kg	Rs. 52/200g	7.04
4	Flavour (strawberry) (0.075%)	0.75 lit	Rs. 200/500ml	300.00
5	Stabilizer (0.075%)	0.75 kg	Rs. 140/kg	105.00
6	Processing cost	-	Re. 1/litre	1000.00
7	Packaging material @3g/pouch	15 kg	Rs. 93/kg	1395.00
8	Whey	800 lit	-	-
Sub total (A)				6912.00
Fixed cost				
1.	Labour Supervisor	1	Rs. 500/day	500.00
2	Plant Operator	1	Rs. 350/day	350.00
3	Attendent	2	Rs. 200/day	400.00
Sub Total (B)				1250.00
Cost of Production (A+B)				8162.00
	COST/POUCH			**1.67**

CHAPTER-5

SUMMARY AND CONCLUSIONS

5. SUMMARY AND CONCLUSIONS

Market demand for beverage and instant foods is growing all over the world. Also pre-eminence of whey as a beverage has been recognized as it is highly nutritious and genuine thirst quencher. Therefore whey has been used in different types of beverages like fruit flavoured, alcoholic, non-alcoholic, fermented, non-fermented and milk like beverages. However, in Indian market, hardly any whey based drink is available commercially. This investigation was, therefore, undertaken with the objectives of developing suitable technology for the manufacture of whey-milk beverage and cultured whey-milk beverage and to ascertain their shelf-stability.

Cheese whey was first heat treated to 72°C to inactivate the residual enzyme in the whey and then used in the formulations. Paneer whey was first neutralized with sodium hydroxide (NaOH) to titratable acidity of 0.14% LA and then used in whey-milk beverage preparation.

The results on the use of cheese and paneer whey separately at 80% level for the preparation of WMB containing 2% fat revealed that cheese whey resulted in a superior product as compared to that obtained from paneer whey.

Among the different levels of cheese whey used in the preparation of WMB admixing of 80% of whey with milk (8.8% fat) yielded most desirable WMB.

In order to improve the mouthfeel and consistency of WMB guar gum was used at different levels. Addition of 0.075% of guar gum to WMB was found to improve the consistency as well as the overall acceptability of the product.

In case of paneer WMB it was found that only 70% of whey could be admixed with milk to obtain an acceptable WMB.

On the basis of this study a method for manufacture of WMB was developed which included heating of cheese whey to 72°C, admixing with milk (8.8% fat), addition of sugar and stabilizer, filtration, homogenization, pasteurization addition of flavour and colour at 4°C, packaging and storage at 4±1°C.

For WMB manufacture from paneer whey the manufacturing scheme included neutralization of paneer whey to 0.14% LA with sodium hydroxide (NaOH), admixing with buffalo milk (6.2% fat), heating to 55-60°C, addition of sugar and stabilizer, filtration, homogenization, pasteurization, addition of flavour and colour at 4°C, packaging and storage at 4±1°C.

In case of cultured WMB use of 80% paneer whey did not yield an acceptable product while the product made with 80% cheese whey was acceptable. However, the product made with admixing of 70% of cheese whey was considered to be the most desirable.

To improve the consistency of the cultured WMB different stabilizers were used at 0.3% level. The results revealed that the use of CMC resulted in a more acceptable product as compared to that obtained with the use of guar gum and pectin.

Cheese WMB stored at 4°C storage showed that product kept well for one week. Paneer whey-milk beverage stored at 4°C kept well for 9 days. Also the cultured WMB at refrigerated conditions (4±1°C) remained acceptable up to 6 days.

Consumer rating for the products showed that 55% and 48% consumers liked very much cheese WMB and paneer WMB respectively, 31% and 23% consumers liked moderately cheese WMB and paneer WMB respectively.

Cost analysis of the product was conducted on a commercial scale point for a pouch with 200ml WMB. The cost of 200ml pouch of WMB and CWMB worked out to be around Rs.1.67 and Rs.2.74.

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APPENDICES

Appendix-I
ANOVA TABLE FOR TYPES OF WHEY IN WMB

SOURCES OF VARIATION	D.F.	MEAN SUM OF SQUARES			
		FLAVOUR	CONSISTENCY	C & A	OVERALL ACCEPTABILITY
AMONG REPLICATES	2	0.1319	0.8334 E-01	0.0012	0.8334 E-01
AMONG JUDGES	5	0.1277	0.7916 E-01	0.1667 E-01	0.1625
AMONG TYPES OF WHEY	1	0.6944 **	0.5625	0.2778 E-01	0.5625 *
INTERACTIONS	5	0.1778	0.7791	0.1778	0.9583
ERROR	22	0.7133	0.1440	0.1363	0.9848 E-01

*Significant($P<0.05$) ** Significant ($P<0.01$)

Appendix-II

ANOVA TABLE FOR LEVELS OF CHEESE WHEY IN WMB

SOURCES OF VARIATION	D.F.	MEAN SUM OF SQUARES			
		FLAVOUR	CONSISTENCY	C & A	OVERALL ACCEPTABILITY
AMONG REPLICATES	2	0.3576	0.4513 E-01	0.4513 E-01	0.9722 E-01
AMONG JUDGES	5	0.2118	0.1305	0.4451	0.1534
AMONG LEVELS OF WHEY	3	0.9606 E-01	0.4351 *	0.6828 E-01	0.1145
INTERACTIONS	15	0.2099	0.1546	0.2044	0.1092
ERROR	46	0.1438	0.1139	0.1212	0.9359 E-01

*Significant($P<0.05$) ** Significant ($P<0.01$)

Appendix-III
ANOVA TABLE FOR STABILIZER LEVELS IN WMB

SOURCES OF VARIATION	D.F.	MEAN SUM OF SQUARES			
		FLAVOUR	CONSISTENCY	C & A	OVERALL ACCEPTABILITY
AMONG REPLICATES	2	0.9027 E-01	0.1134	0.8334 E-01	0.1319
AMONG JUDGES	5	0.2097	0.3009 E-01	0.1430	0.1334
AMONG LEVELS OF STABILIZER	5	0.1319	0.4523 **	0.1652	0.1817 **
INTERACTIONS	25	0.1808	0.1312	0.1475	0.1734
ERROR	70	0.1402	0.9675 E-01	0.1023	0.1271

*Significant($P<0.05$) ** Significant ($P<0.01$)

Appendix-IV
ANOVA TABLE FOR LEVELS OF PANEER WHEY IN WMB

SOURCES OF VARIATION	D.F.	MEAN SUM OF SQUARES			
		FLAVOUR	CONSISTENCY	C & A	OVERALL ACCEPTABILITY
AMONG REPLICATES	2	0.4629 E-02	0.1296	0.4166 E-01	0.2268
AMONG JUDGES	5	0.2269	0.3963	0.5277 E-01	0.1518
AMONG LEVELS OF WHEY	2	0.1296	0.6018 E-01	0.1250	0.3240 E-01
INTERACTIONS	10	0.1074	0.9351 E-01	0.8611 E-01	0.9907 E-01
ERROR	34	0.9286 E-01	0.8551 E-01	0.9558 E-01	0.6508 E-01

*Significant($P<0.05$) ** Significant ($P<0.01$)

Appendix-V
ANOVA TABLE FOR TYPES OF WHEY IN CULTURED WMB

SOURCES OF VARIATION	D.F.	MEAN SUM OF SQUARES			
		FLAVOUR	CONSISTENCY	C & A	OVERALL ACCEPTABILITY
AMONG REPLICATES	2	0.6944 E-01	0.6250 E-01	0.2500	0.1944
AMONG JUDGES	5	0.2277	0.6667 E-01	0.1166	0.1903
AMONG TYPES OF WHEY	1	0.1111	0.4445	0.1111	0.5625
INTERACTIONS	5	0.4611 **	0.2111	0.3444 *	0.1125
ERROR	22	0.9785 E-01	0.1609	0.1287	0.1035

*Significant($P<0.05$) ** Significant ($P<0.01$)

Appendix VI
ANOVA TABLE FOR LEVELS OF CHEESE WHEY IN CULTURED WMB

SOURCES OF VARIATION	D.F.	MEAN SUM OF SQUARES			
		FLAVOUR	CONSISTENCY	C & A	OVERALL ACCEPTABILITY
AMONG REPLICATES	2	0.4629 E-01	0.3240 E-01	0.4167 E-01	0.8796 E-01
AMONG JUDGES	5	0.2629	0.3268	0.2222	0.2268
AMONG LEVELS OF WHEY	2	0.3240 E-01	0.1435	0.1250	0.6018 E-01
INTERACTIONS	10	0.1101	0.1101	0.2974 *	0.7129 E-01
ERROR	34	0.1223	0.1255	0.1299	0.1909

*Significant($P<0.05$) ** Significant ($P<0.01$)

Appendix VII
ANOVA TABLE FOR TYPES OF STABILIZERS IN CULTURED WMB

SOURCES OF VARIATION	D.F.	MEAN SUM OF SQUARES			
		FLAVOUR	CONSISTENCY	C & A	OVERALL ACCEPTABILITY
AMONG REPLICATES	2	0.2824	0.5279	0.3240 E-01	0.2916
AMONG JUDGES	5	0.4379	0.4379	0.9351 E-01	0.1555
AMONG TYPES OF STABILIZER	2	1.4074	2.1157	0.4074 E-01	1.5416 **
INTERACTIONS	10	0.2074	0.2327	0.9613 E-01	0.1972
ERROR	34	0.1059	0.7325 E-01	0.9613 E-01	0.1151

*Significant($P<0.05$) ** Significant ($P<0.01$)

Appendix VIII

CONSUMER RATING OF FLAVOURED DAIRY DRINK

Kindly give your opinion on the products acceptability using the following scale (please tick ✓)

Liked extremely	:	( )
Liked very much	:	( )
Liked moderately	:	( )
Liked slightly	:	( )
Neither liked nor disliked	:	( )
Disliked slightly	:	( )
Disliked moderately	:	( )
Disliked very much	:	( )
Disliked extremely	:	( )

Remarks, if any,

Signature:_____

NAME

Appendix IX

SCORE CARD FOR EVALUATION OF FLAVOURED DAIRY DRINK

Product_____

You are requested to assess the products in terms of geneal acceptability on the9-point Hedonic scale, as below :

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neitehr like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

CHARACTERISTICS	SAMPLE NUMEBR				
	1	2	3	4	5
Flavour					
Consistency					
Colour & Appearance					
Overall acceptability					

(Remarks if any)

Sign _____

Name