POTENTIAL USE OF WHEY FOR DEVELOPMENT OF VALUE ADDED BEVERAGES IN SMALL-SCALE PROCESSING SECTOR

Abstract

This chapter explores how the dairy sector is changing, with a particular emphasis on the rise of whey-based drinks. Whey is a byproduct of producing cheese that is being investigated for its nutritional worth, which includes vitamins, minerals, and proteins, making it a perfect choice for creative beverage preparation. Whey-based drinks are divided into two groups in this chapter: non-fermented and fermented, each with its own special qualities and difficulties. Fruit-flavored drinks, concentrated fruit-based drinks, and natural fruit juice/pulp drinks are examples of non-fermented whey beverages. Fermented whey drinks are made when bacteria convert lactose to lactic acid. This process produces a variety of goods, including carbonated drinks, fermented whey drinks, and cultured dairy products. The chapter also discusses the issue of whey disposal, with a focus on small-scale cheese producers, underscoring the need of environmentally responsible and sustainable disposal techniques. It talks on the benefits of whey-based drinks, emphasizing their high protein content, health advantages, and ability to appeal to a wide range of consumers. Furthermore, the market potential for whey beverages is explored, with a bright future in the growing demand for functional and protein-rich drinks. Finally, this chapter acknowledges the possibilities and obstacles in the manufacture and marketing of whey-based drinks, including the need to address environmental issues, and offers insights into the potential of these products as nutritive and marketable goods.

Keywords: Alcoholic, Beverages, Fermented, Non-Fermented, , Non-Alcoholic, Whey

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I. INTRODUCTION

India has been the world leader in terms of milk production for decades (Sain et al., 2020), with a current yearly production of 221.1 MT (NDDB, 2022). The dairy industry has developed a number of nutritionally improved products (Patwadi et al., 2021) that have had significant commercial success. Consequently, the traditional dairy products we have been familiar with for decades are evolving into a new generation of goods with distinctive characteristics and greater nutritional and health benefits. Whey, a byproduct of producing cheese, is occasionally thrown away as trash or utilised as a provender, but whey-based beverages unquestionably fit within this category of inventive goods.
A by-product of the cheese-making process is whey. Depending on how casein is coagulated, whey can either be acidic or sweet. According to Jelii (2008), the technology used to manufacture cheese and the quality of the milk used in cheese manufacturing have the most effects on the composition and properties of whey.

II. COMPOSITION

According to Panghal et al. (2007), whey comprises approximately 45–50% of the total milk solids, 70% of milk sugar (lactose), 70–90% of the minerals, 20% of the milk proteins, and nearly all of the water-soluble micronutrients present in milk (Singh et al., 2021). During the cheese-making process, various quantities of water-soluble vitamins are transferred into the whey, ranging from 55-75% of vitamin B6 and pantothenic acid to 40-70% of vitamin B12, 80-90% of thiamine, nicotinic acid, folic acid, and ascorbic acid, and 70-80% of riboflavin and biotin found in milk (Singh et al., 2014). During rennet coagulation, the greatest quantity of vitamin B12 is transferred into the whey, as opposed to acid coagulation.

Major proteins and minor proteins are subclasses of whey proteins. The majority (65%) of whey proteins consist of beta-lactoglobulin (b-Lg), alpha-lactalbumin (a-La), immunoglobulins (Ig), bovine serum albumin (BSA), and proteose peptones. Lactoferrin, lysosome, Glycomacropeptide (GMP), phospholipoproteins, and lactoperoxidase are examples of minor whey proteins. Only egg proteins surpass whey proteins in terms of protein efficiency ratio (3.6), net protein utilisation (95), and biological value (110). Additionally, they surpass soy protein, casein, wheat gluten, and beef. In addition to the nine essential amino acids, whey protein contains all 20 amino acids. Methionine and cysteine, two amino acids containing sulphur, are present in significant amounts (Macwan et al., 2016). In addition to being rich in calcium, magnesium, phosphorus, and trace levels of zinc, whey also contains a number of other minerals that are the building blocks of electrolytes. Because lactose promotes the absorption of magnesium and zinc, it is believed to be helpful in treating diarrhoea (Narayanan, 2013). This superior nutritional mix is responsible for a wide range of neutraceutical advantages, such as a decreased risk of atherosclerosis, obesity, diabetes, cancer, and even Alzheimer's and HIV, as well as immune-stimulating, disease-controlling, and antitoxin activity. Whey sulphur amino acids inhibit cancer through one-carbon metabolism and as precursors of the potent intracellular cell reinforcement glutathione (Krol et al., 2017).

The best and most enticing way to use whey for human consumption is to make it into beverages, which can be done either with or without fermentation. It is a good development for the use of whey when the proper proportions of fruit juice, pulp, and whey are used to generate a new product (Panghal et al., 2009). Whey beverage is sweet, light, and better for you than other drinks because it actually satisfies your thirst. It has a lower acidity than fruit juice as well. The qualities of whey beverages are influenced by a number of factors, including pH, solubility, dispersibility, colour, preparation methods, and extra ingredients included in the formulation. Since the 1970s, when whey beverages were first produced for sale commercially, a variety of whey-based drinks, including alcoholic, carbonated, fruit-flavoured, plain, and fermented beverages, have been created (Panghal et al., 2018).

III. THE PROBLEM OF WHEY DISPOSAL IN SMALL SCALE PROCESSING SECTOR

Whey disposal may be difficult for small-scale cheese manufacturers. They frequently use their whey as a waste product by feeding it to animals or spreading it on their fields. Whey can be used as fertiliser, however use of it can harm aquatic life and taint waterways (Goel et al., 2022).

Whey disposal can be expensive for creameries, which could be the difference between their company prospering or failing in a market with slim profit margins and high volume. For small-scale cheese producers, the annual cost of whey generation ranges from 300,000 to 600,000 rupees (Durham et al., 2007). Alternative disposal techniques call for using cheese whey as fertiliser because of its high nutrient content. However, these techniques provide environmental risks because of the high biological oxygen demand (BOD) and chemical oxygen demand (COD). There are numerous valorisation processes that can turn whey into useful and highly beneficial products. Although technologies like membrane filtration can be employed, not all kinds of whey can be treated in this way. Innovative methods that are adaptable enough to deal with whey variability can be used to produce valorized products (Buchanan et al., 2023).

IV. CLASSIFICATION OF WHEY-BASED BEVERAGE

Whey beverages majorly can be classified in two ways (Figure 1):

1. Non Fermented
2. Fermented

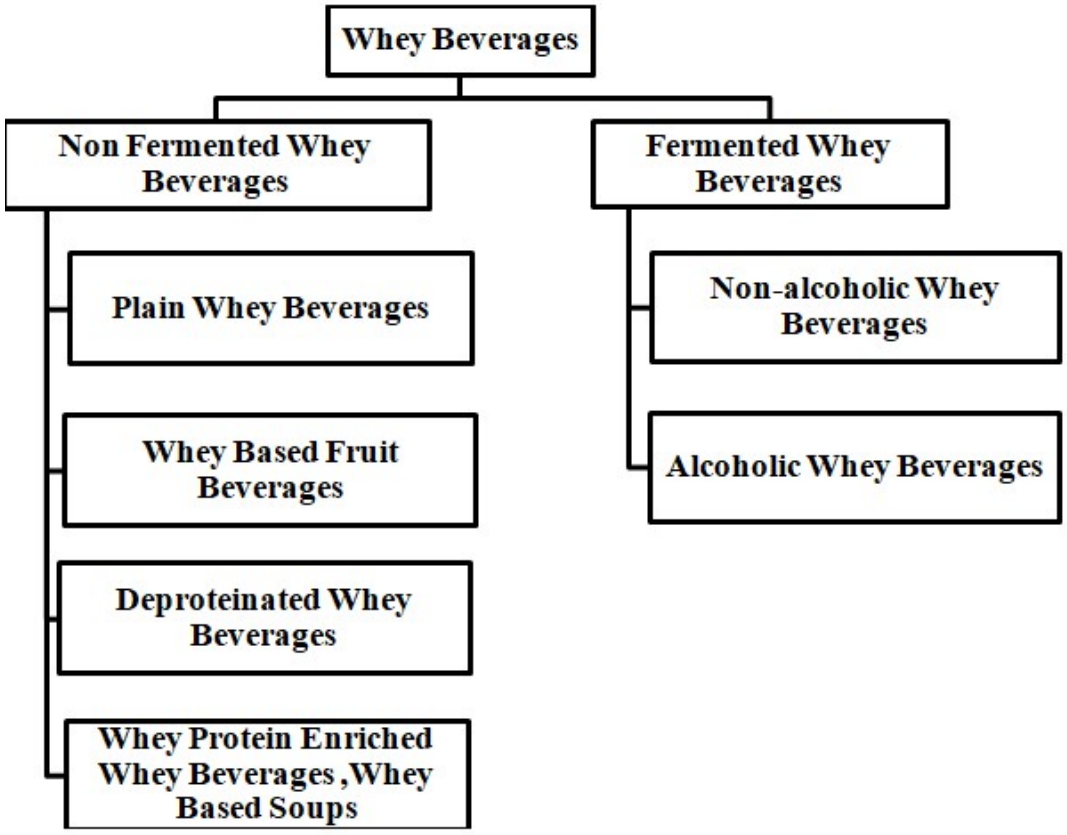

Figure 1: Classification of Whey-Based Beverage

V. NON-FERMENTED WHEY-BASED BEVERAGES

Non-fermented whey beverages are made with native sweet, diluted, or acid whey and a variety of additives, such as tropical fruits (but also other fruits like apples, pears, strawberries, or cranberries), crops and their byproducts (primarily bran), vegetable protein isolates, CO2, chocolate, cocoa, vanilla extracts, and other aromatizing agents. Non-fermented whey beverages will be the main area of discussion. Fruit-based whey beverages can be divided into different categories based on the type of raw material utilised and different processing conditions.

1. **Whey Based Natural Fruit Juice/Pulp Drink:** The product's (Figure 2) low protein and high carbohydrate content are its defining characteristics. Due to the high lactose content in whey, the amount of carbohydrates is large. The successful products' overall personalities resemble fruit juices with a slightly thicker body.

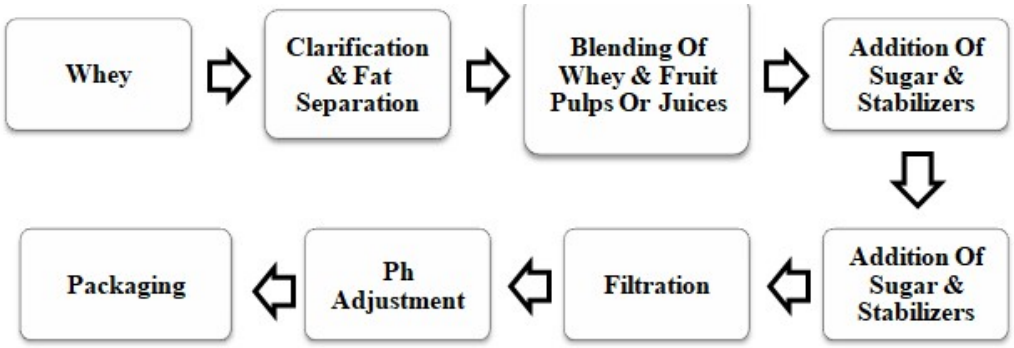

Figure 2: Flow Chart for Manufacturing of Whey based Natural Fruit Juice/Pulp Drink (Source: Kumar, 2014)

2. **Concentrated Fruit-Based Whey Beverages**

These beverages have been developed for the following reason:

- To deliver the product in a more convenient form,
- To minimize the transportation and packaging requirement
- To improve the protein content.

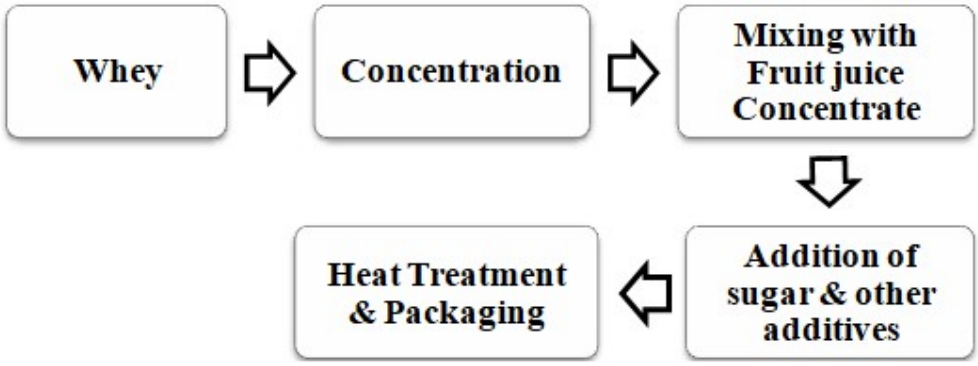

Figure 3: Flow Chart for Manufacturing of Concentrated Fruit based Whey Beverages (Source: Kumar, 2014)

In order to prepare such products, the whey is first concentrated using evaporators or a vacuum pan, then it is combined with fruit juice concentrate, sugar, and many other additions before being heated, processed, and packed.

3. **Fruit Flavoured Drinks**: In this type of whey-based fruit beverage, different types of fruit flavours are used which may be artificial and natural.

The primary issue with fruit-based whey beverages is:

- Due to the high fruit dry matter content and interactions between proteins and fruit dry matter components, turbidity forms in the beverages.

- If the quantity of dried fruit is insufficient, the final product will not have excellent sensory properties in terms of colour, aroma, and fragrance (Koffi et al., 2005).

One of the better options for beverages with acceptable sensory properties manufacture is the production of fermented whey beverages.

VI. FERMENTED WHEY-BASED BEVERAGES

Fermented whey beverages are made when lactose in whey is converted to lactic acid by lactic acid bacteria (LAB). Whey-based fermented drinks, whey-based fermented carbonated drinks, and whey-based cultured dairy products are the three main categories into which these drinks can be categorised.

Fermentation, one of the earliest ways of food preservation, also naturally converts dairy byproducts into meals with added value that provide nutritional advantages in addition to flavour. Kluyveromyces yeast is primarily used for alcoholic fermentations, whereas lactic acid bacteria are primarily used as starter and probiotic cultures for whey fermentations. It has been suggested that by microbially fermenting whey with particular strains of yeast, probiotics, and prebiotic microorganisms, a variety of pleasant beverages can be produced. Whey is a superb growth substrate for lactic acid bacteria because it contains a lot of lactose, the main fermenting ingredient. After fermentation with lactic acid bacteria, it becomes a beverage that lactose-intolerant people can drink. Lactic acid imparts a fresh flavour, masks the influence of the curdy whey flavour, and is known to prevent the growth of harmful spoilage organisms, according to Skryplonek et al. (2019).

Whey is fermented to create fermented whey beverages using either yeast or lactic acid bacteria. Lactose is converted into lactic acid when lactic acid bacteria ferment whey. This process gives the beverage a fresh flavour and masks the influence of the curdy flavour of whey, making it ideal for those who are lactose intolerant. The term "non-alcoholic beverages" is used to describe these drinks.

Alcoholic drinks contain lactose, which yeast converts to alcohol (ethanol) during the fermentation of whey. Depending on how much alcohol is present in the beverage, we can classify it as:

- Alcoholic Beverage having (< 1.5 % alcohol content)
- Whey beer
- Whey wine
- Whey champagne

1. **Non-Alcoholic Whey Beverages:** Whey, a liquid byproduct of producing cheese, is used to make non-alcoholic whey beverages. Whey has been demonstrated to provide a lot of health advantages and is a strong source of protein, calcium, and other nutrients. Non-alcoholic whey drinks can be produced with a wide range of different ingredients and flavours (Kumar, 2014). Non-alcoholic whey beverage categories that are popularly available include Whey smoothies: These are smoothies made with whey protein powder, fruit, and other ingredients.

- Smoothies produced with whey protein powder, fruit, and other ingredients are known as whey smoothies. Whey smoothies can serve as a nutritious and energising lunch substitute as well as a rich source of protein and other minerals.
- Whey drinks: These are libations flavoured with whey protein powder and water. Whey beverages can be a tasty and practical method to achieve your recommended daily dose of protein. They are a good source of protein.
- Whey-based sports drinks: Sports drinks formulated with whey protein powder, electrolytes, and flavourings are known as whey-based sports beverages. Sports beverages using whey as an ingredient can aid in post-workout rehydration and refuelling.
- Whey-based functional beverages: Beverages produced with whey protein powder, probiotics, and other useful additives are known as "whey-based functional beverages." Functional beverages made from whey may assist to strengthen the immune system, support weight loss, and enhance gastrointestinal health.

For those seeking a protein-rich, hydrating beverage that is also nutritious and non-alcoholic, whey drinks are a wonderful choice. They are also a suitable choice for those who cannot consume lactose, as whey protein powder frequently contains no lactose (Kumar, 2014).

Additional details about non-alcoholic whey beverages are provided below:

Here are some additional benefits about non-alcoholic whey beverages:

- The protein content of non-alcoholic whey beverages can vary from 10% to 30%.
- Non-alcoholic whey beverages are typically low in calories and fat.
- Non-alcoholic whey beverages can be a good source of probiotics, which are beneficial bacteria that can help to improve gut health.
- Non-alcoholic whey beverages are often lactose-free, making them a good option for people who are lactose intolerant.

One of the important Non-alcoholic beverages is Acido-whey. It was developed at National Dairy Research Institute, Karnal. It is a non-carbonated drink, fermented having a specific strain of lactic acid bacteria. L. acidophilus strain is used for the manufacture of Acido-whey.

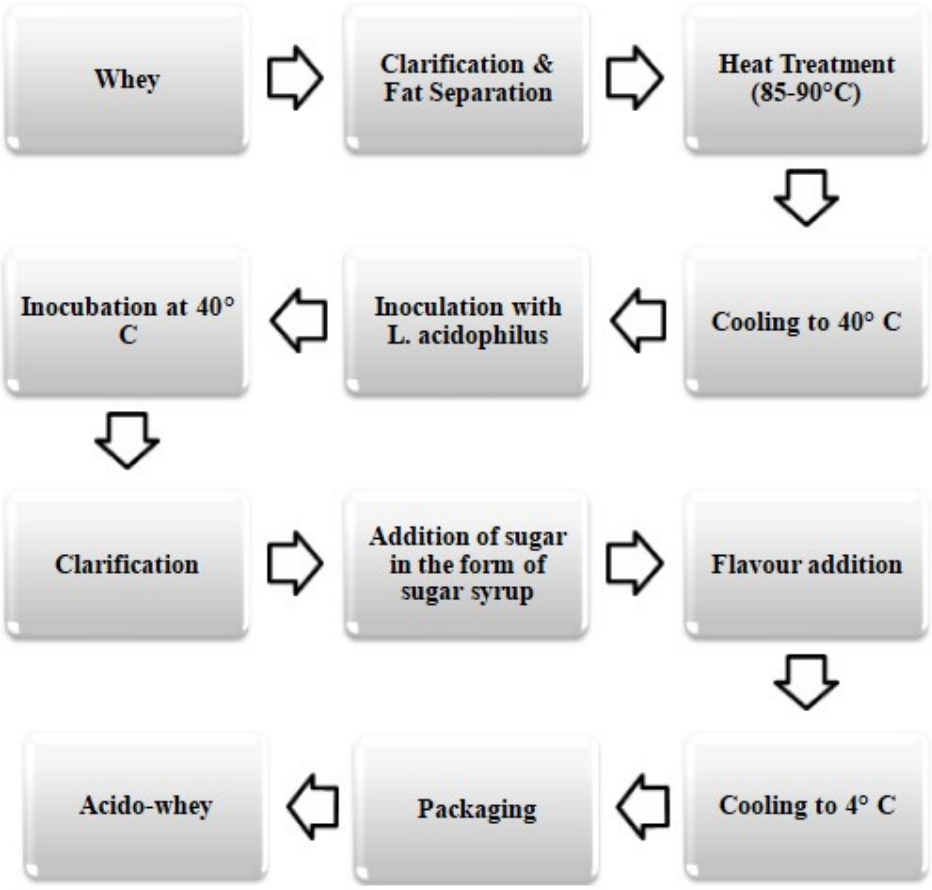

Figure 4: Flow Chart for Manufacturing of Non-Alcoholic Whey Beverages
(Source: Kumar, 2014)

2. **Alcoholic Whey Beverages:** Whey, the liquid waste product of producing cheese, is used to make alcoholic whey beverages. Whey has been demonstrated to provide a lot of health advantages and is a strong source of protein, calcium, and other nutrients. Alcoholic whey beverages can be produced using a wide range of yeasts and come in a variety of flavours (Zer et al., 2022).

   The following are some of the most popular kinds of alcoholic whey beverages:

   - **Whey Beer:** This variety of beer is produced using whey rather than water. Whey beer can be full-bodied and nuanced or have a light, refreshing flavour.

   - **Whey Ale:** Whey is used to make this particular variety of ale. Whey ale frequently has a fruity or citrusy flavour and is typically lighter in colour and substance than whey beer.

   - **Whey Stout:** This variety of stout is produced using whey.

- **Whey Porter:** Porter that uses whey is known as a "whey porter." Whey porter is less sweet than whey stout, but it often has a dark colour and a roasted or chocolatey flavour.

- **Whey Cider:** This variety of cider is produced using whey. Whey cider often has a pale colour and an acidic or tart flavour.

- **Whey Wine:** This kind of wine is produced using whey. Whey wine often has a white colour and a sweet or dry flavour.

Although they are a relatively new type of beverage, alcoholic whey drinks are gaining popularity. They can be a tasty and refreshing substitute for other alcoholic beverages, and they are a rich source of protein and other nutrients.

Additional details about alcoholic whey beverages are provided below:

- The alcohol content of alcoholic whey beverages can vary from 3% to 10% ABV.
- Whey beverages are typically low in calories and fat.
- Whey beverages can be a good source of probiotics, which are beneficial bacteria that can help to improve gut health.
- Whey beverages are often lactose-free, making them a good option for people who are lactose intolerant.

One of the important alcoholic beverages is Whevit. It was developed at National Dairy Research Institute, Karnal. It is a carbonated drink, fermented having a specific strain of yeast. ‘Saccharomyces cerevisiae’ yeast is used for the manufacture of Acido-whey.

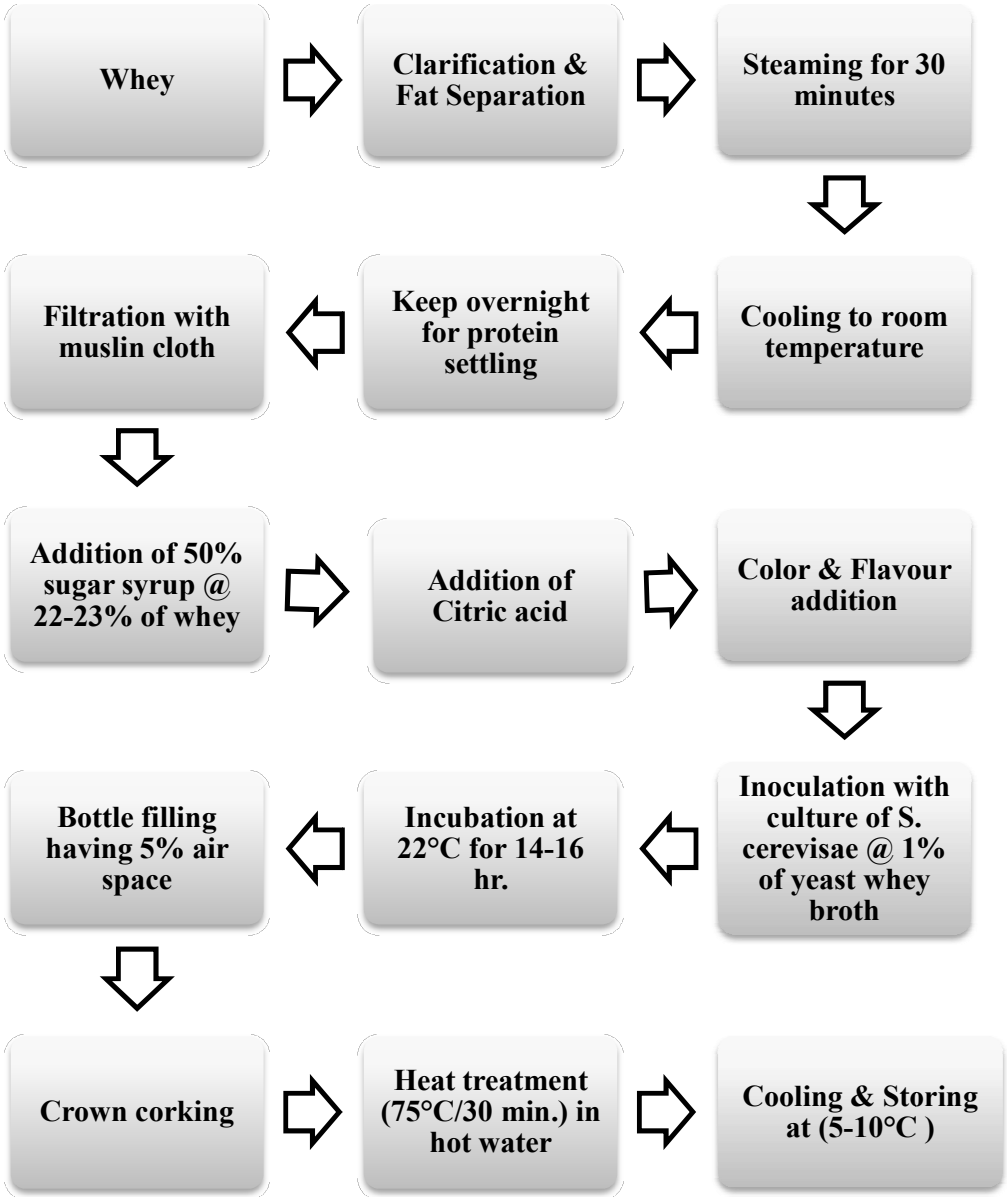

Figure 5: Flow Chart for Manufacturing of Alcoholic Whey Beverages
(Source: Kumar, 2014)

VII. PROBLEMS OCCURRING DURING WHEY BEVERAGE PRODUCTION

Due to its high water content, fresh whey needs heat treatment to prevent microbial degradation. Whey proteins are thermosensitive and will denature at temperatures above 60 °C (Tratnik, 1998). As a result, extensive research is done into replacing heat treatments with membrane techniques like microfiltration or ultrasonic.

When whey is acidified down to pH 3.9, whey proteins become thermoresistant and do not precipitate even after UHT sterilisation treatments (Jelen, 2003). Whey's unwelcome

salty-sour flavour is brought on by minerals. Due to better solubility, the amount of minerals (mostly Ca-phosphates and Ca-lactates) is also higher in acid whey due to the higher amounts of lactic acid (Tratnik, 2003).

Since Hippocrates suggested whey for a number of human illnesses about 460 B.C., cheese whey has been used in human nutrition, primarily for therapeutic purposes. The global beverage market is getting more concentrated; functional beverage trends are diverging internationally; taste advancements; product differentiation; and cross-category innovations are the five primary factor categories that drive the market dynamics. When making and formulating whey beverages, the nutritional advantages, biological traits, and functional properties are taken into consideration.

According to Chavan et al. (2015), the main issues that are typically present in whey-based fruit juice beverages are as follows:

1. Lactose crystallisation while being kept at a cold temperature
2. Whey protein coagulation during heat treatments
3. Concentrates with a higher viscosity reduce the efficiency of thermal treatments
4. Shelf-life degradation at ambient temperatures
5. A high mineral content in the whey is what gives it its unfavourable salty-sour flavour.

VIII. ADVANTAGES

Whey-based beverages are now a growing market due to their several advantageous aspects, some of which are the followings (Jeli et al., 2008),

1. Whey-based beverages appeal to a wide range of consumers, including both adults and young children.
2. They rank among the finest methods for using whey.
3. The high protein content of whey beverages makes them good sources of nutrition and energy (Sherwood et al., 2007).
4. Whey beverages can be utilised as a functional component to enhance iron absorption from food and/or prevent infections from adhering to intestinal walls since they contain lactoferrin (Miller, 2005).
5. These beverages may enhance calcium absorption, which is crucial for the ageing population, which frequently experiences osteoporosis.(2005) Miller.
6. Since Ancient Greece, whey has been used to heal ailments.
7. Specialised facilities for using whey to treat ailments were constructed in the 18th century.
8. Due to their high protein content, whey-based beverages become excellent sources of fuel and minerals for athletes.
9. Alpha-lactalbumin, lactoferrin, and glycomacropeptide (GMP) are among the whey protein components.
10. People with milk protein allergies or celiac disease should drink fortified beverages made with rice and oat bran and isolates of soy and potato proteins.
11. The hypotensive effect of whey beverages has been demonstrated in numerous clinical investigations.

12. They are also utilised as a nutritious substitute for fast food by athletes, senior persons, and those with weight problems as well as meal replacements.
13. They effectively slake one's thirst.
14. They have excellent isotonic qualities.
15. They are uplifting and light.
16. They have significant profit margins.
17. They are less acidic than fruit juices.

IX. MARKET POTENTIAL

Numerous articles claim that the future of whey beverages on the market is very bright. Whey beverages are drinks that contain whey protein, a by-product of milk that has a number of health benefits, such as promoting immunity and weight loss. Over the next five years, the market for ready-to-drink protein beverages, which includes whey beverages, is expected to expand at a CAGR of 7.72%. Demand for beverages with additional protein would significantly expand as a result of consumers' propensity to maintain their health and knowledge. The market for whey protein in India is expected to grow at a CAGR of 9.5% over the next five years due to the increased popularity of functional foods and beverages, especially among young people. Whey protein sales were valued at $10.26 billion globally in 2021, and through the year 2029, they are anticipated to grow at a CAGR of 7.4%. Whey protein is mostly used in pet food, cosmetics, personal care items, food and beverages, and dietary supplements. With approximately 48.0% of the total revenue in 2021, the food and beverage application segment dominated the global whey protein market. Whey protein is an ingredient in tens of thousands of products produced both domestically and internationally. The market for functional beverages was estimated at US $25 billion in 2005 (Chavan et al., 2015).

X. SUMMARY

But despite all of the difficulties, it has been shown that digesting fresh whey is the most economically sensible technological solution. Various efforts have been made to develop beverages with the addition of fruit concentrates in order to create a beverage with acceptable sensory qualities, notably in terms of flavour (Koffi et al., 2005).

Whey-based beverage production and distribution have actually been hampered by a financial problem. It has often been demonstrated that it is not practicable to produce whey beverages that can be sold in the United States at a price that is competitive with that of snack beverages or, in the case of a high-protein whey beverage, fresh or dried milk. But severe pollution limits have reignited interest in restoring the minerals lost in whey. As a result, whey beverages—which until now have mostly been an intriguing laboratory curiosity—might turn out to be financially viable (Holsinger et al., 1974).

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