FORMULATION AND QUALITY IMPROVEMENT OF WHEY BASED FRUIT DRINK

By

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DECLARATION

The work described in this thesis carried out by me at the Newdale Dairies (Pvt.)Ltd., 100, Delgoda Road, Biyagama under the supervision of Mr. N.S.Pathirana and Mrs. W.M.Deepika Priyadharshini. A report on this has not been submitted to another university for another degree.

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Affectionately Dedicated

To

My loving parents

And

Teachers

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Abstract

Cheese whey nutritious by-product of cheese manufacture contains all of the nutrients of milk except fat and casein, plus the vitamins developed during the cheese making. This by-product contains 90% of total milk input. Therefore study was carried out to develop whey based fruit drink with good consumer acceptability.

Five treatments were given by changing the percentage level of whey powder as 40%, 60%, 70%, 80% and 100%, while keeping other ingredients constant. Samples were evaluated organoleptically by a group of experienced panelists using nine-point hedonic scale. Acidity and pH were monitored at 4 days intervals during the 4±1°C, 15±1°C, and 25±1°C storage for 40 days. Final product was analyzed for total solids, pH, acidity and Brix value. Yeast and mould count and Total plate count were also taken. Pectin, RecodanRs and Carboxy Methyl Cellulose (C.M.C) were tested as stabilizers.

Whey based fruit drink prepared with 80% level of whey powder was rated as the best on the basis of sensory quality. No significant differences were found through out the 40 days of storage period for pH and acidity. Finish product specifications for the 80% level of whey powder fruit drink were 13.0% total solids, 4.0 pH, 0.20 acidity, 12° Brix value with negative aerobic plate count and Yeast & mould count. The results indicated that the Carboxy Methyl Cellulose was the most suitable stabilizer to prevent the sedimentation in the final product. The final product specifications are within prescribed standards with a fair storage of 40 days at 4°C, 15°C, and 25°C with out any deterioration of quality parameters. The production cost of 1 Kg of whey based fruit drink also could be Rs. 12.57 and development of low cost whey based fruit drink is feasible.

These experiments were shown clearly, that whey powder is an excellent starting point for beverage when it was added in ratio of 80%: 20% whey to skim milk powder respectively, with added fruit flavour. More than 40 days of storage life without any physical change could be achieved regardless of storage temperature when it was given UHT treatment.

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CHAPTER 1

1. Introduction

The ancient Greeks used whey, a greenish-yellow clear substance that gets out of the cheese curd during draining process, as a drink, especially to re-establish human health. Although whey has lost the image of a universal remedy it is still considered as healthy. The negative image of whey is further intensified because it is also used as animal feed.

This negative image of whey is not the only problem, which the dairy industry has to deal with. For dairies the main problem is the huge quantities of whey which is obtained during the cheese making process. When using traditional methods 1-Kg milk is transferred into approximately 0.17Kg cheese and approximately 0.83 Kg whey. It is clear that by-product of cheese contain nearly 90% of total milk input. Since 90% of total milk input is remaining as a by-product, each cheese producing country produced several million tons of whey every year.

Whey classified into two groups, Acid and sweet, according to their manufacturing procedure. Acid whey is resulting from acid-casein, quarg or cottage cheese manufacturing while sweet whey is resulting from cheddar cheese or rennet casein manufacture. Fresh fluid whey resulted from both ways consist 0.9% protein, 0.3% fat, 6.9% total solids.

In addition, vitamins such as biotin, Pantathonic acid, Pyridoxine, Folacin, Inositol, Cloline, and Vitamin B_{12} are found in dry whey and are considered to be important from a nutritional stand point.

Though whey is nutritionally significant by-product it very cheap because of the large quantities and only limited possibilities of using whey. Although it seems that whey is scarcely worth mention, it cannot be considered as a waste product. Whey has a high Chemical Oxygen Demand (COD), which is about 100 times higher than the waste from households. If the whey is passed to the sewage plant, the dairy whey will have to pay high capitol cost. On the other hand proper disposal of whey becomes a necessary with the increased demand for environmental concerns. Therefore this valuable by-product become a problem for dairies those who have not proper sewage plant.

Concerning its high nutritional value and disposal problem numerous different methods have been suggested for utilization of whey. On simple whey is drying of whey to powder and substitution of other, more expensive proteins, in the dairy and bakery industry. Whey also has been separated in to lactose and proteins. Lactose is a good starting point for biotechnological processes, to gain ethanol or lactic acid. Also some experiments to transform whey in to beer or champagne have been done. (Sienkiewicz and Riedel, 1990)

Beside these new technologies for whey utilization, whey is still use to produce drinks. Although some international dairies and cheese producing factories sell whey drinks at their market. It is not get practiced in the country.

It is important to combine whey drinks with fruit juice since consumer doesn't accept plan whey drink in refreshing and delicious. On the other hand there will be wide product verity. Every one will able to find on the retailer shelves are plain whey drinks or whey drinks combine with fruit juices.

Industries do not have to make big investments to obtain more sophisticated product out of whey, like dessert or novel kind of drinks. Drinks are particularly interesting, because the equipment for preparing and filling are already available in the dairies.

The formulation and introduction of whey based fruit drink offers the consumer to a totality new taste, which can result in a more sophisticated image of whey drinks with excellent marketing opportunities.

Therefore this study was carried out with the following objectives.

- Development of low cost whey base fruit drink as a thirst quencher and refresher
- Introduction of the whey drinks to the Sri Lankan market.
- Development of nutritious soft drink.

CHAPTER 2

2. Literature review

Whey is the greenish- yellow clear substance that gets out of the cheese curd during the draining process. It is the rich source of proteins diverse food properties for nutritional, biological and functional applications. Therefore it's use as an ingredient in the production of the various food items would be favorable.

This by-product of cheese production contains 90% of total milk input. But it's solid content is only around 5% to 6%.

Milk and its by-products contain exceptional food values at the most economical cost. They supply more of the essential nutrients in significant amount than any other single food. Cheese whey, which is a nutritious food by-product, contains the entire nutrients of milk except fat and casein, plus the vitamins developed during the cheese making. Whey can make valuable contribution in food processing, lactose the dominant component, is responsible for most of the flavor intensification observed when whey or lactose is added to many food products. However 100 ponds of milk going in to cheese manufacture only 9 pounds become cheeses. The balance has a high (Biological Oxygen Demand) BOD and is there fore difficult to dispose of by conventional means; consequently, raw whey is regarded as a serious pollutant and its disposal is receiving increasing attention from pollution and central authorities. (Vadji and Peraira, 1973)

Just a few decades ago whey was the most difficult waste produced at he cheese factories, and were simply pour down the drain. As factories grew, the volumes of whey increased and it become valuable component.

The traditionally the whey problem has been resolved by using the substance such as for a livestock nutrients and by dehydrating it to for a powdered feed.

The high cost of transport and rapid spoilage restricts the use of whey as a feed for livestock, and high-energy costs have made dehydrating unprofitable. New uses must be found for whey, as the problem is growing along with increasing production of cheese through out of the world.

Use of whey as a raw material for food products has been hindered by its reputation as a waste derived from cheese manufacture. Only in very recent years have substitutional improvements in its reputation. Nowadays whey is even known as a health food item, and this will open new prospects for marketing of whey products.

With the increasing in the production of cheese, the more stringent controls on disposal of waste materials, the use of surplus cheese whey is the one of the most critical problems facing dairy industry. When the liquid that remains after casein and fat are separated as cards in the cheese making process, contains most of the salts, lactose and water-soluble proteins of the milk. If various in compositions with the type of the cheese from which it comes, that heats treatment handling and other factors. The predominant type is "sweet whey", which is derived from manufacture of ripen cheese (Cheddar, Swiss, Provolone etc.), so named because its pH is only slightly less than that of fresh milk. Acid Whey on the other hand, has a pH of approximately 4.7;it is similar in composition to sweet whey, except that up to 20% of the lactose is converted to lactic acid by fermenting bacteria in manufacture of products like cottage cheese.

The reduced pH may also be achieved by the addition of food grade acids to replace lactic cultures, as directly acidified cottage cheese.

Even through liquid whey has been successfully commercialized in the form of alcoholic and nonalcoholic beverages. Most whey is converted to whey solids as ingredients for human food or animal feeds by traditional processors such as spray drying, roller drying, and concentration to semisolid blocks, or production of sweeten condensed whey. Reported other traditionally established processes including lactose crystallization from untreated or modified whey, production of heat denatured whey protein concentrate, or recovery of milk fat from whey cheese in "whey butter".

Some limitations in the functional properties of dried whey for human foods including high salt and lactose concentrations, have led to its fractionation and blending into variety of new products. (Wong et al, 1960)

The whey in the form of a beverage is, technologically, the simplest method for utilization in human food chain.

The whey base may consist of whole whey or Deproteinized whey, from which the fat has been removed by centrifugal separation. Deproteinized whey is produced by ultra filtration of whole whey or by heat/acid precipitation of the proteins and is used where a clear drink is desired.

Whole whey can be classified into two groups for beverage applications. (a) Acid whey, resulting from acid-casein, quark or cottage cheese production and (b) sweet whey, resulting from cheddar cheese or rennet casein manufacture.

A pH of less than 4.0 is necessary to prevent protein sedimentation as a result of the heat treatment used to pasteurize still whey-based fruit drinks. Consequently, sweet whey must be acidified by fermentation with lactic acid bacteria or directly with lactic acid or other suitable organic acids.

Milk sugar (lactose), which is present in whey, is not as sweet as the sugars naturally present in fruits, such as fructose and sucrose, and consequently it is necessary to sweeten whey-based fruit drinks. This can be accomplished by the addition of sugars, syrups, honey or various low-caloric sweeteners.

A pasteurizing heat treatment is sufficient to preserve whey based fruit drinks because of their low pH (pH<4.0) (Tuohy et al, 1987). The whey proteins are heat labile and are denatured by heat treatment in excess of the minimum milk pasteurization conditions. (72°C for 15s). Whey protein denaturation, which manifests itself in the form of sedimentation during storage, can be minimized in whey-based drinks by adjusting the pH down to 3.5-4.0 before heating.

Conventional high-temperature short time (HTST) plate heat exchangers are suitable for pasteurizing most whey drinks but for those containing fruit juices as some orange juices with a high content of fruit cells or fruit pulp in suspension, special wide-gap plate heat exchangers or tubular heat exchangers may be necessary. Carton-filling equipment of the type used for milk is suitable for packaging pasteurized whey-based fruit drinks and a shelf life of 2-3 weeks at refrigeration temperatures is attainable. For extended shelf life, without refrigeration, aseptic packaging or hot filling is necessary (Tuohy et al, 1987).

2.1 Historical background of whey

Mr.E.W.Evans, Head of Physical Department, National institute for Research in Dairying, Shinfield has done research on whey. A major assumption is that uses for whey should not compete with existing markets for skim milk powder (SMP), Thus Jelen's (1979) suggestion that whey should be blended with caseinates, soy protein products, corn solids or SMP followed by spray drying to produce so-called Dairy blends as replacements for more expensive skim milk powder. This thing conmen in America, (Jonas et al. 1976) on the premise that neither the United States nor the rest of the world can any longer depend entirely on traditional protein sources for human nutrition. They too have their eyes set on a wide range of protein containing new materials, of both animal and vegetable origin, that are available for dairy analogue manufacture. (Evans, 1980)

Research in the Dairy Technology, Department at Moorepark has shown that whey based fruit drinks with high consumer acceptability can be produced. Following product development work in the AFT pilot-scale processing facility, 'Clona Dew' from Srand Dairy Ltd., will be the first home produced whey-based fruit juice drink to be launched on the Irish market. The per capita consumption of fruit juice in Ireland is six liters per annum comp aired with twenty-two liters per annum in Germany and twenty-six liters in Switzerland. (Tuohy et al, 1987)

Mr.Vadji and R.R.Peraira, March 1973 have done the previous studies about the feasibility of whey utilization for the production of various drinks. In their study, three different product varying in flavour and the type of ingredients used were prepared. To adjust the pH of liquid whey, a sufficient amount of 0.1 KOH was added to the whey until the pH of 6.7 was established. Appropriate amounts of ingredients were added to stainless steel containers and stirred vigorously to obtain a homogenous mixture. After homogenisation, the product was cooled immediately to 45°F and bottled in commercial size containers. The finish product was kept under refrigeration.

Dr. Carmen Schwab was studied about whey drink with citric acid. He emphasized a very fast and easy way to obtain a sour whey drink is to add food grade acids until the desired pH is reached. All of the common food acids can be used, e.g. citric acid, lactic acid... In this test a citric acid solution (50%) was used in dosage of 0.4%, which led to an end pH of 4.0-4.5.

Kevin (1985) has done experiments on development of whey drinks from whey powder. Whey powder, stabilizer, crystal sugar, flavour, fruits and water were used to develop his product. Whey powder was dispersed into cold water. Stabilizer mixed with sugar and added to whey mix. Fruit concentrates were added and pH was adjusted to 3.6-4.2. Hold in 90°C for 30 minutes. Hot filling was done in 75°C and cooled.

2.2 Importance of whey as a soft drink

There is a nothing new in the consumption of whey. Its beneficial effects were known to the ancient Greeks and down trough the countries to the present day. When has been used to treat a wide variety of aliments such as arthritis, anemia and liver complains (Kevin, 1985). How ever hard economics have forced a reassessment of its uses, but for the British at least this is still in its infancy.

When drinks are very powerful if correctly handle as follows;

(1) This is a genuine thirst quencher, unlike most soft drinks.
(2) Whey drinks are light and refreshing but less acidic than fruit juices.
(3) Heath and nutritional arguments.
(4) Good potential profit margins.

Whey as a thirst quencher

The loss of body fluid from excretion, temperature or age, gives rise to thirst, which is offset by drinking. The lost are also accompanied by a loss of electrolytes; vitamins, Lactates, amino-cellular fluid and this reduced concentration of substances alter the osmotic balance between the cells and their surrounding fluid. This imbalance is communicated to the brain and sanitation of dryness of the mouth we know as thirst occurs.

A whey drink much replace much of the lost organic and inorganic to the extra cellular fluid. Whey, which is so rapidly assimilate, forms on ideal metabolic substrate. Milk can satisfy hunger and thirst but being a fat emulsion is assimilated more slowly.

Whey drinks are refreshing and light

Pure fruit juice as a breakfast drink has grown dramatically in recent year but in general consumption of more than a small glass 100-150 ml is difficult due to its high acidity.

Whey drinks, which have a higher pH 3.8-4.2, are lighter in mouth feel and less astringent.

Health and nutrition arguments.

The main beneficial components of whey are as follows:

L (+) Lactic acid, Calcium, Phosphates, Vitamin B_1, B_6, B_2, amino acids.

Lactose:

The presence of lactose encourages the utilization of Calcium, Sodium and Potassium from the food consumed as easily absorbed complex mothers milk is high in lactose.

L (+) Lactic acid:

Culturing the whey during production of drink increases the level of metabolically active L (+) Lactic acid.

Minerals:

Calcium, Phosphates, Potassium, Sodium, Magnesium.

Vitamins: Vitamins of the B group are indispensable to the metabolism and levels of B_1 are generally considered to inadequate. Other essential vitamins present in whey are B_2 and B_6.

Protein amino acids:

The percentage of protein in sweet and sour whey is one average 0.5-1.0%, compared with 3.5% protein in milk. In spite of reduced preparation of protein, essential and non-essential amino acids can be found on a biologically active from in heated and fermented whey. During this technical processing there is a loss of Lysin, Leucine, Phynol alanine, Asporitic acid and Glutamic acid.

Profitability

It will be demonstrated that most whey drinks are produced with 85% fruit concentrate, sugar and stabilizer. Raw material costs are there fore cheaper than 100% fruit juice. We have also demonstrated that an equally refreshing, but cheaper drink, can be produced with lower whey content (Hence reduced stabilizer level) and, of course lower fruit content supplemented with flavor.

The utilization of the whey as a drink gives two-fold advantages.

(a) Large volumes of whey are used direct from the cheese vat eliminating disposal problem.

(b) Simple processing and common equipment requirement. (Kevin, 1985)

2.3 composition and structure of whey

2.3.1 Composition of whey

Whey contains lactose and natural milk salts as well as a substitution part of the salt added in cheese making. Whey consists of some casein, about 0.1 per cent fat and the soluble proteins of milk.

Whey is the by-product from manufacturing of cheese, casein, quarg and another sour-milk products. In quantity of cheese whey is by-product, which is the most important.

Whey is not a product of defined chemical composition. The composition varies considerably with the product from which it is derived and with the manufacturing procedure. There are many kinds of cheese, which all yield different whey, and often products (for instance sodium chloride or Calcium Chloride) are added during the cheese manufacture, and as these products are water soluble, they will be present in whey.

Normally whey contains approximately 6% solids, which is half of the total solids of the original milk. The most valuable constituent of whey solid is protein fraction, which amount of 20% of the total protein content of the milk. The whey contains almost all the vitamins of the original milk.

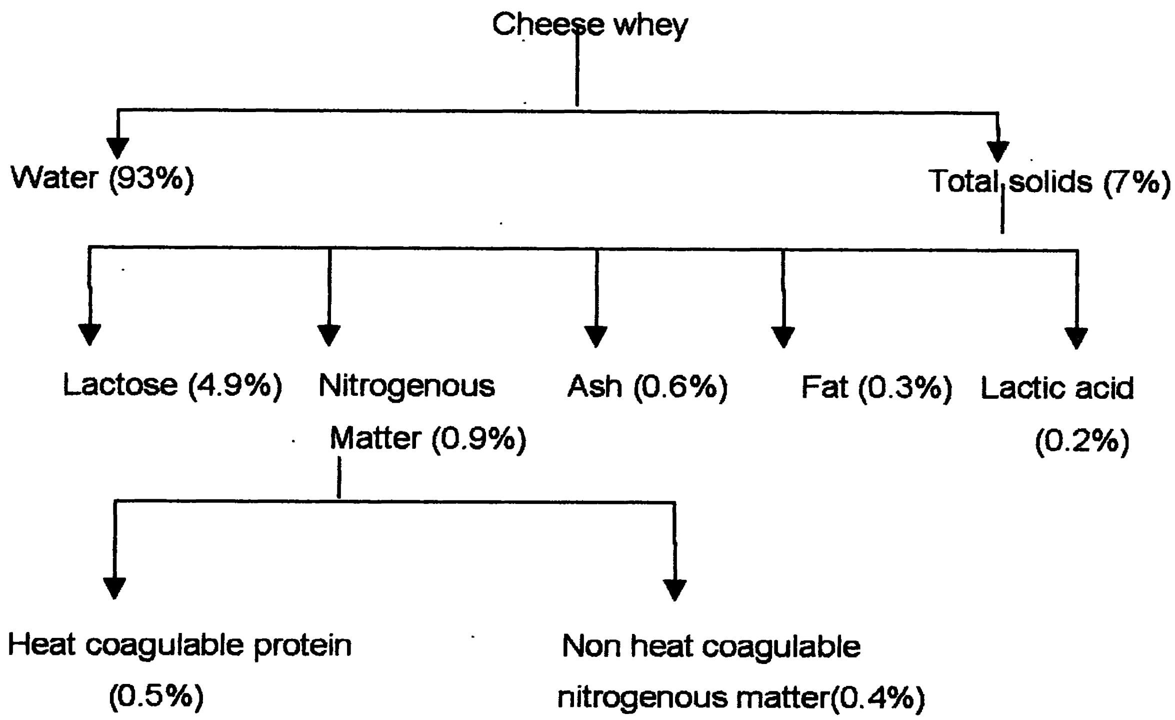


Figure 2.1 Compositional illustration of cheese whey

Source: Nutting, 1969

Table 2.1 Composition of cheese whey and skimmed milk (Amount/100g)

COMPONENT	WHEY	SKIMMED MILK
Water (g)	90.3	93.1
Food energy (Kcal)	36.0	26.0
Protein (g)	3.6	0.9
Fat (g)	5.1	05.1
Lactose (g)	0.7	0.6
Ash (g)	12.1	51.6
Ca (mg)	95.0	53.0
P (mg)	Trace	0.1
Fe (mg)	52.0	-
Na (mg)	145.0	-
K (mg)	Trace	10.0
Vitamin A (I.U)	0.04	0.3
Thiamin (mg)	0.18	-
Riboflavin (mg)	0.1	0.14
Niacin (mg)	0.1	0.1
Ascorbic acid (mg)	1.0	-

Source: Nutting, 1969

The food values of dried whey as a dietary supplement comparing other sources is unprofitable and it is indicated in table 2.2.

Table 2.2: Composition and food value of dried whey, dried butter milk, dried whole milk and dried non fat milk (w/w)

Component	Dried non fat Milk (%)**	Dried whole Milk (%)	Dried butter Milk (%)	Dried whey * (%)
Protein	36.0	26.0	12.5	12.5
Minerals	8.2	6.0	12.5	9.0
Lactose	51.0	38.0	48.0	72.5
Fat	0.7	26.7	5.0	1.0
Moisture	3.0	2.25	3.5	5.0

*350 Calories per 100 grams

**359 Calories per 100 grams

Source: Nutting, 1969.

Table 2.3 shows the compositional changes according to the type of whey.

Table 2.3 Compositional changes according to the type of whey. (%)

Type of whey	Moisture	Fat	Protein	Lactose	Ash	Lactic acid
Chenna whey	93.6	0.5	0.4	5.1	0.4	0.2
Cheddar cheese Whey	93.0	0.3	0.9	4.9	0.6	0.2
Acid casein Whey	93.0	0.1	1.0	5.1	0.7	0.4

Source: Nutting, 1969.

2.3.2. Whey proteins.

The supernatant after casein in milk is precipitated at the isoelectric point (pH 4.6) contains several proteins that are correctively called whey proteins. The whey proteins mainly include four proteins, namely β-lacto globulin (59%, molecular weight =18600), α-lactalbumin (22% molecular weight = 14400), bovine serum albumins (molecular weigh = 67000) and immunoglobins (molecular weigh = 160000). A number of other minor proteins, correctively called the protease fraction, include mostly proteolysis products of caseins. (Larsson et al, 1990) Whey proteins have a more defined, compact, globular shape than the casein. This structure is due to the formation of disulfide bonds (as a result of the cysteinyl residues present), the lack of phosphate groups, so that they do not react with Ca or aggregate together in the native state. The functional properties of whey proteins become more apparent after heating of the milk temperatures above 80°C, where they are denatured and react/bind with k-casein to form a more stable micelle. (Tamine and Robinson, 1985)

The whey proteins divide into two groups. An albumin fraction precipitated by addition of Ammonium Sulfate and acidification and globulin fraction, which stays in solution.

Table 2.4: Proteins in whey

Milk	**gl**	**Approx. mol. Wt.**
Whey protein	7	
β-lacto globulin	3.2	18,400
α-lactalbumin	1.2	14,000
Lactoperoxidase	0.03	76,000
Immunoglobulin	0.9	160,000
Bovine serum albumin	0.3	70,000
Proteose peptone	1.2	10,000 to 200,000
Lactoferrin	0.02	93,000

Source: Evans, 1980

The albumin fraction consists mainly of α-lactalbumin and β-lactoglobulin which as genetic variants. α-lactalbumin and β-lacto globulin contain 1.9 and 1.6 percent sulfur respectively. β-lactoglobulin is very sensitive to pH, temperature and ionic charge; under particular conditions it unfolds to expose sulphydril groups, which may be readily oxidized with the result that intermolecular bonding, and thus polymerization occurs. These reactive side groups are responsible for the important functional characteristics of lacto globulin. (Evans, 1980) Lacto peroxidase is another component of this fraction, an enzyme which catalyses transfer to oxygen from peroxides and is probably the most abundant enzyme in cow's milk.(Evans, 1980)

The globulin fraction consists of proteins that confer immunity. Those structures have much in common and whose specificity depends on regions of the molecules, which have valuable amino acid residues. Their concentrations change through lactation, being particularly high in colostrums and decreasing rapidly during the first few days after parturition.

Whey also contains proteose peptones, a mixture of heat stable, acid-soluble. Phosphoglycoproteins are characteristically insoluble in 12 per cent trichloracetic acid.

Most whey proteins are not denatured under normal pasteurization conditions. But their denaturation is complete when whey is heated for an hour at 77°C.The implications to procedures for increasing the incorporation of whey proteins in to Cheddar cheese will be touched on later. (Evans, 1980)

2.3.3. Whey protein products.

The whey, which contains 93%water and only about 6% protein, must be concentrated to produce the various whey protein ingredients. These whey protein products can be classified on the basis of their composition. They are usually grouped based on their protein contents (on a dry weight basis).

2.3.3.1 whey powder

The spray dried cheese whey is referred to as whey powder. It contains about 10% ash, 1% fat, 76% Lactose and 13% proteins (Evans, 1980). Since the lactose content is rather high, it is called as sweet whey powder.

2.3.3.1.1 typical composition of cheese whey solids

Lactose	70%
Proteins	14%
Minerals	9%
Lactic acid	3%

The acid content of the whey varies with the length of time acid is kept and the storage conditions. During storage under certain conditions, a portion of the lactose will ferment and lactic acid will be formed. The whey should be pasteurized and cooled immediately it becomes from the cheese vat to prevent further acid development. But in many cases the heat treatment and cooling of the whey is neglected, with the result that the content of the lactic acid is increased.

2.3.3.2. Whey protein concentrates (WPC)

Powder containing high concentration of whey protein, usually in a denatured state is called as whey protein concentrates (WPC). The composition of WPC varies with the preparation process, which is used to concentrate dilute solution of whey before it is spray dried to a powder, and it is shown in table: 2.6;

Table 2.6: Composition of whey protein concentrates compared with standard preparation methods.

Preparation process	Protein %	Lactose %	Ash %	NPN %	Fat %
Metaphosphate Complex	55.7	13.0	13.7	1.2	5.3
Electrodiolysis	32.9	51.8	9.0	6.7	3.3
Ultrafiltration	56.5	27.2	3.4	4.8	7.3
Gel filtration	41.9	24.9	1 1.5	4.9	0.8
Dialysis	66.0	26.2	2.0	1.5	2.0
CMC complexing	49.8	20.1	8.0	-	1 .2
Iron complexing	35.1	0.8	54.0	1.1	0.6

Source: Gillies, 1974.

The composition of the different whey protein concentrates, grouped according to preparation process, is given in protein table 2.6. The ranges and mean values for protein, lactose, ash, and fat percentages are given on a dry basis. Mean protein contents varied from 32.9% (electro dialysis) to 66% (dialysis). Dialysis WPC was prepared in the laboratory by exhaustively dialyzing pH 4.6 whey against distilled water and freeze-drying.

Mean lactose content varied from 0.8% (Iron complex) to 51.8% (electrdiolysis). Mean ash content varied from 2% (dialysis) to 54% (Iron complex). The mean fat content varied from 0.6% (Iron complex) to 7.3% (ultra filtration). These data show wide compositional variations within a given WPC process and even wider variation between the composition of whey protein concentrates prepared by different processes. The high lactose and ash-to-protein ratio in the starting whey makes it difficult to prepare a WPC with greater than50 to 60% protein, even by exhaustive dialysis and protein complex precipitation processes.

Table 2.7: contains elemental analysis data for the different whey protein concentrates. Although they are not shown here, the analysis included also Mg, Mb, Mn and Bo. The met phosphate and electro dialysis whey protein concentrates used in this part of the study were only the acid form; they were not neutralized with Ca $(OH)_2$, NaOH, or KOH.

Thus, the analysis reflects their inherent compositional prior to the addition of any other elements. (Gillies, 1974)

Table: 2. 6 Elemental analysis of whey protein concentrates.

Preparation process	P	K	Ca	Na	Fe	Al	Zn	Cu
	Per cent				p.p.m			
Metaphosphate complex	04.00	01.50	-	0.30	-	34.00	14.10	47.90
Electrodialysis	1.03	02.20	00.69	03.22	-	144.0	16.00	16.00
Ultra filtration	0.59	03.29	0.67	0.98	-	-	59.10	80.70
Sephadex	0.94	02.89	0.75	01.91	-	202.0	41.80	167.2
Dialysis	-	02.54	0.39	0.63	-	59.0	23.50	41.6
CMC complex	-	01.67	-	03.40	217.0	404.0	33.00	41.20
Iron complex	12.50	01.97	0.49	0.58	-	94.0	48.90	123.0

Source: Gillies, 1974.

Whey protein concentrates are further grouped based on their protein content.

35% WPC

It is a powder containing 34-35% protein, 53% fat and typically 4% fat and 8% ash. This composition is similar to that of non-fat dry milk. Hence can be used as milk powder replacer.

50% WPC

The 50% WPC contains about 53% protein, 35% lactose, 5%fat and 7% ash. (Huffman, 1996)

8% WPC

In 8% WPC, the protein concentration increases to 8% , the lactose content decreases to about 7% and the fat and ash range between 4-7%.

Lactalbumin

This is the special type of WPC, which has been heat denatured and shows different functional properties.

Whey protein isolates

This is virtually all protein (greater than 90%) with only 1% fat, 1% lactose and 3% ash. (Huffman, 1996)

2.3.4. Properties of whey proteins

2.3.4.1 Solubility and denaturation of proteins

Whey proteins that are not heat denatured show excellent solubility over a wide range of pH. However, heating to temperatures above 70°C can cause partial loss of solubility between pH 3-5, because some of the whey proteins aggregate and precipitate at their iso-electric point (pH4.5-5.3) (Muller, 1987). Even with a heat treatment of 90°C for five minutes at an aqueous solution of WPC, more than 80% of the whey proteins remain in solution. The solubility of whey proteins in heated products can be increased by the addition of sugar, which improves the heat stability of whey proteins. In application, which has yogurt, acid beverages and salad dressings, the good acid solubility of whey proteins is very important. (Muller, 1987)

2.3.4.2 Viscosity and water holding capacity

Heating of whey proteins causes an increase in viscosity and water holding capacity, but a decreasing in solubility as already discussed. The partial unfolding of the protein by heat expose additional water-binding sites that's were unavailable in the native heated protein and increases the volume occupied by protein thus the increasing the viscosity. (Huffman, 1996)

The ability of whey protein concentrate (WPC) to increase viscosity with heating is used to thicken foods, such as soups, sources and yogurt . Jenness and Batton (1973) have reported the most important fact that the, viscosity of 10% solution of pre-heated reconstituted whey powder has a greater stability with increasing temperature than that of reconstituted skim milk powder.

2.3.4.3 Gelation

Whey protein products from irreversible gels by restructuring into extended three dimensial network under appropriate heating conditions. Gelation entraps water within the capillaries of the gel matrix; thus providing additional water holding capacity. A strong gel network helps to hold this water and prevents moisture loss (syneresis) (Huffman, 1996). This can improve the appearance of various food products such as yogurt, by preventing surface moisture.

Whey proteins start to gel when heated to around 65°C. The nature of the gel characteristics can vary from curdy, syneresis gels to smooth, shiny, strong elastic gels similar to egg white. The temperature to initiate gelation and the nature of the gel depends on the protein concentration, pH, other food ingredients in the solution, and the processing conditions.

In aqueous solutions, whey proteins begin to gel at concentrations of 7% protein. In food systems, the other ingredients influence the amount of available water and enable gel forming at 0.5 to 3.0%whey protein concentration.

Gelation properties of whey proteins can be used to modify the textural characteristics of food products, such as hardness, cohesiveness, and elasticity and also to change liquid or favorable products in to solids. (Huffman, 1996)

Solution of WPC with sufficient protein content 7-10% can give firm gels when heated at 72-85°C. The temperature of gelling, the firmness and structure of the gel vary as a function of the preheated treatment given to the whey, the protein level in the solution, the pH and same additives such as Calcium and carrageenam. (Muller, 1987)

2.3.4.4 Adhesion

Whey proteins provide good adhesion properties to improve the homogenous texture of a food product. For example, they may be used to improve the spoon ability of stirred yogurt because, of the adhesion property of the whey proteins. (Huffman, 1996)

2.3.4.5 Emulsification

Whey proteins have both hydrophilic and hydrophobic regions and thus act as emulsifiers. Further more, whey proteins are thought to form interfacial membranes and oil or water globules that prevent creaming, coalescences and oiling off. After adsorption at the fat globules, because whey proteins maintain their solubility under acidic conditions, they perform well in such applications as yogurt and salad dressings. In addition, whey proteins can provide emulsion stability in heated foods, such as yogurt and sauces, through their thickening and gelling properties. (Huffman, 1996)

The emulsifying ability of whey protein concentrate solutions can be at least as a good as that of sodium caseinate. Muller, 1987 derived the influence of heat treatment on emulsifying ability of whey.

2.3.4.6 Foaming

Foaming of protein solutions can be desirable in such foods as frozen desserts, cakes and whipped toping, and is undesirable in other foods as yogurts and fruit juice fortifications. The formation of foam is analogous with the formation of an emulsion. The stabilizing whey protein interface is formed around the air micelle.

2.3.4.7 Whipping

WPC solutions with 10% protein can give good whips. However, the whipping properties can vary. The presence of more than 2% fat can adversely affect whipping and there is some evidence in that whip ability is affected by the temperature history of the sample, pH, clarification, Calcium level and the addition of such materials as sucrose and hydrolyzed starch. (Muller, 1987)

2.3.4.8 Colour

With cheese whey the increase in protein aggregation, which occurs as teat treatment of the whey becomes more severe, is reflected in increased whiteness of the WPC. Casein WPC, even after low heat treatment, are whiter than cheese WPC. (Muller, 1987)

2.3.5. Functional properties of whey proteins

2.3.5.1 Commercial processes

The whey formulae make a caramel with a fine flavor. It is possible to make a very light caramel with little or no colour when only sweetened condensed whey is used. Caramels made from sweetened whey and soy proteins come close to matching the flavour or texture that is imparted by the serum solids found in skim milk or whole milk.

Confectioner's or compounds coating resist summertime deterioration. Widespread acceptance has resulted in year round use. For the most part, the coating consist of hard vegetable fats, sugar and dried milk powder. Spray or roller dried whey powders are finding increased use in these products.

For space foods, coating contain high-melting fats (135°F) to reduce the rate at which these bite size products disintegrate in the mouth. These coating help the solubility of the piece. At the same time, they do not produce a waxy sensation in the mouth.

2.3.5.2 Dairy products

In ice cream: Probably the largest single use of whey in diary products is in ice cream. The use of whey in ice cream up to 25% of the non-fat milk used, and now most states also permit this usage level. As a result many millions of pounds of whey solids are used each year in ice cream.

Originally, attempts to use whey in ice cream resulted in what were commonly called sandy ice cream. Lactose from the whey would crystallize in ice cream during frozen storage and would give a gritty or sandy mouth feel. The problem was solved by the proper selection and use of stabilizers, which controlled the crystallization of the lactose.

In addition, in early usage there were serious problems with flavour, both off-flavours due to poor handling and burned flavours due to drying methods. The present method of handling whey for edible use, basically in just as sanitary a manner as fresh milk, assure freedom from the off-flavours associated with uncontrolled fermentation.

In cheese foods: Another large dairy for whey is in cheese foods. These are softer bodied than regular processed cheese, partly because of the added whey solids, but this is recognized and desirable feature of these cheese foods. The consumer finds them much easier to use in making sandwich filling, such as pimento cheese.

These cheese foods melt more readily and are preferred for use in sauces and of course, in toasted cheese sandwiches. Whey is used too, in the even softer bodied prepared cheese spreads, which are very popular. Whey is useful in these products, because it accentuates the cheese flavour and seldom causes any off-flavour as other ingredients might.

Cheese starter media: Another potentially large use for whey is in making a starter media for cheese production. The bacterial culture used for making cheese is built up from small laboratory quantities to large batch cultures or starters, which are then added to tanks of milk to form the cheese curd. Non-fat milk solids customarily have been used for making these bulk cultures, but the product had to be carefully selected to make it did not contain phage, the bacteria disease organisms which would interface with normal growth of the desired culture bacteria.

2.3.6 Fractionation of whey proteins

Techniques for the isolation of individual whey proteins on a laboratory scale by salting-out; ion-exchange chromatography and/or crystallization have been available for about 40 years. Owing to the unique functional, physiological or other biological properties for many of the whey proteins, there is an economic incentive for their isolation on and industrial scale. For example, β-lacto globulin, the principle whey protein in bovine milk, produces better thermo set gels than α-lactalbumin. However human milk does not contain β-lacto globulin, which is most allergenic of the bovine milk proteins for the human infant; therefore, α-lactalbumin would appear to be a more appropriate protein for the preparation of infant formulae than total whey protein.

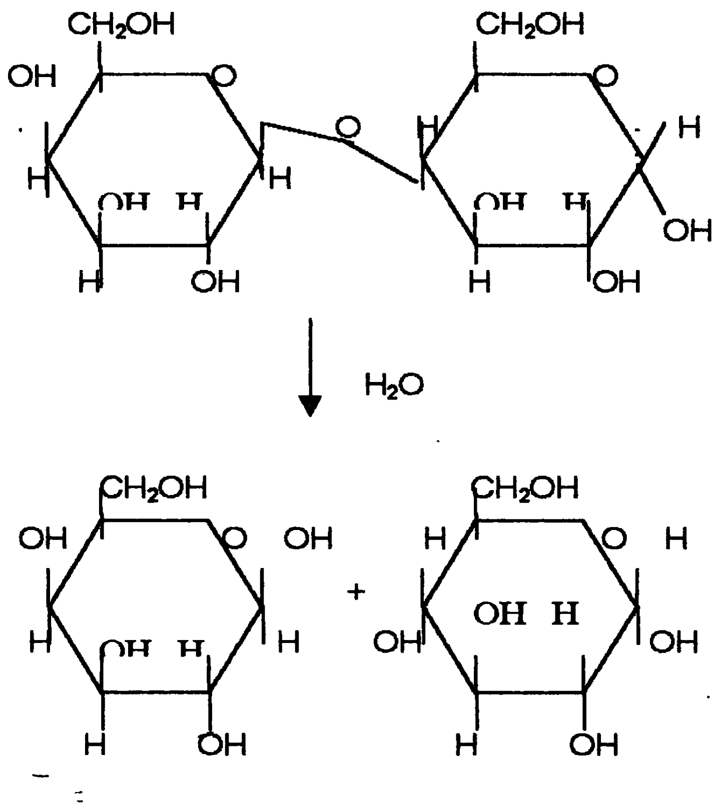
A number of methods have been developed for the separation of α-lactalbumin and β-lacto globulin. Probably the most commercially feasible of these exploits the low heat stability of Calcium free α-lactalbumin to precipitate it from whey, leaving β-lacto globulin, BSA and Ig in solution α-lactalbumin loses its Calcium in acidification to about pH 5.0, aggregates on heating to about 55oC and can be recovered by centrifugation, filtration or micro filtration.

2.4 Hydrolysis of whey

Lactose or milk sugar is the main component of whey dry matter. Conversion of lactose by means of hydrolysis to glucose and galactose broadens the scope of whey use. Hydrolysis increases the sweetness and solubility of lactose.

Hydrolysis of whey is nothing new, and in principle it can be achieved with either acid or enzymes. The use of acid, however calls for separation of the whey proteins, which is troublesome and expensive process. To day, only the batch process has been available for enzyme hydrolysis of lactose on an industrial scale; this means adding the enzyme to the product, Because of the high price of the enzyme, this method has in general not been commercially feasible. In order to curb enzyme costs, valio has developed a method in which a bound enzyme is used.

Lactose



β, D-Galactose α, D-Glucose

Figure 2.2 Hydrolysis of lactose

2.5 Nutritional properties of whey

Whey proteins contain all the essential amino acids and they are easily digested. The processing method of whey affects the content of available amino acids present in two different milk products.

Because of their well-balanced content of the essential amino acids, WPC have high nutritional quality. The WPC from lactic casein whey and pre-heated HCl casein whey have similar high nutritional values to those reported for WPC by other workers. The average protein efficiency ratio (PRE) was 3.2 compared with casein 2.3. The WPC were to be good supplementary proteins for soy protein and flavour. (Muller, 1987)

CHAPTER 3

3.0 Materials and Methods

The research was conducted at the laboratory of the Newdale dairies (Pvt.) Limited, 100, Delgoda road, Biyagama, Sri Lanka.

The preliminary tests were conducted to select the most suitable powder among whey powder and skim milk powder.

1.5% of powder was used to prepare this whey-based fruit drink. Preliminary three samples were prepared with 100% whey powder, 100% skim milk powder and 50% of skim milk powder with 50% of whey powder.

It was found from the preliminary trial and error test, that the desirable range of whey powder was between 50% to 100%. The 100% skim milk powder added sample was rejected.

3.1 Experiment 1: formulation of whey based fruit drink

Whey powder, skim milk powder, sugar, orange juice were weighed and added some water into the mixture. Then mixture was blended for five minutes using laboratory blender. During the later part of the blending pre melted pectin was added to the blended mixture. Flavours and colours were added to it and mixed well. Then pH was adjusted by 10% of critic acid solution and it was between 3.8-4.2. The samples were subjected to heat treatment. It was cooled and poured in to bottles. Then the product was transferred to the cold room. The production flow sheet was sketched in the figure 3.1.

Weigh all the ingredients

(Whey powder, skim milk powder, sugar, fruit juice, pectin, water)

↓

Put in to the blender　　　　Pectin solution

↓

Blending ← (Pectin solution)

↓

Add remaining water

↓

Add flavors and colours

↓

Adjust the pH in to 4 by using 10% citric acid solution

↓

Heat treatment (105°C for 1 minute)

↓

Filling

↓

Storage

Figure 3.1 The preparation of whey based fruit drink.

- Preparation of pectin solution

  Hot water was add to the pectin and sugar mix and stirred well in a water bath. (Around 80° of temperature)

3.1.1 Determination of appropriate whey: skim milk powder ratio

The whey based fruit drink was prepared as per the method described above. The whey powder and skim milk powder was added in different percent levels, while keeping other ingredient constant. Table 3.1 shows the percentages of whey powder and skim milk powder used in different treatments.

Table 3.1 percentages of whey powder and skim milk powder used in different treatments.

Treatment	Treatment code	Percentage of Whey powder (%)	percentage of skim milk powder (%)
1	586	40	60
2	122	60	40
3	345	70	30
4	404	80	20
5	826	100	0

3.1.1.1 Evaluating organoleptic qualities

Three taste panels were carried out organoleptic evaluation during the period of October at the laboratory of Newdale Dairies (Pvt.) Limited. The objective of conducting three taste panels using same panellists was evaluate the sensory properties of three replicates of five treatments in order to reduce the bias.

The organoleptic characters were tested for thickness, taste, mouth feel, and overall acceptability. The panel was consisted of 25 experienced panellists.

3.1.1.2 Testing Criteria

The nine point hedonic scale was to evaluate the degree of liking for particular quality attribute. (Annexure 1)

3.1.1.3 Serving of samples

The samples were coded with three digit random numbers drawn from a random number table. Samples were served in a random order and evaluated by one panellist at a time. The panellists were provided with distilled water and asked to rinse their mouth after each tasting.

3.1.1.4 Statistical Analysis

A non-parametric ranking procedure was used with kruskall wallis test for the evaluation of thickness, taste, mouth feel and overall acceptability. Data were analysed using the software MINITAB. A significance level of 0.05 was utilised for all the analysis.

3.1.2 Selection of most suitable stabilizer.

There was sedimentation presented in whey based fruit drink, which the pectin was used as the stabilizer. So different stabilizers added while keeping other ingredients constant. Carboxy methyl cellulose and RecodenRs with seakem CM611 were tested stabilizers instead of pectin. The samples were stored at the selected storage temperatures and observations were made with the time period of shelf life evaluation.

3.2 Experiment 2: Assessment of physico- chemical properties of whey based fruit drink

3.2.1 proximate Analysis of the product

The finally developed sample was analysed for proximate composition of total solids, titrable acidity, pH, and Brix value using standard methods.

Sartorius AG GOTTINGEN MA 30-000V3-moisture analyser was used to detect total solids in final product. Mettler Toledo MP220 pH meter was used to determine the pH. The Brix value was determined by using ATIGO Refrectometer type 1T.All these tests were done in replicates.

Determination of titrable acidity

9 Milliliters of the sample was taken into a 100ml Erlen mayer flask and 1ml of 1% Phynophthalein solution was added to it. Then the sample was titrated with 0.1N NaOH until a permanent very pale colour was observed.

$$\text{Titrable acidity \% (W/V)} = \frac{90 * N_1 V_1 * 100}{1000 * 9}$$

Where N_1 = Normality of NaOH

V_1 = Burette reading.

Determination of pH

Before begin the experiment pH meter was calibrated using buffer solutions of 4 and 7 . The electrode was rinsed with distilled water and blotted with a soft tissue. The pH meter was inserted to the sample and kept for a while to stabilized the reading. Then the stabilized reading was extracted and recorded.

Determination of Brix value

Very minute quantity of sample was placed on the Brix meter (refractometer) and the read value of Brix by degree of reflection of light.

3.2.2 Acidity and pH development during the storage

Acidity and pH of the samples were checked at 4 days intervals during the storage at three different selected temperatures, as 4°C±1, 15°C± 1 and 25°C±1.

Mettler Toledo MP220 pH meter was used to determine the pH. Acidity was measured by using above described titration. Data were analyzed using Randomized Block Design with the help if the SAS statistical package.

3.2.3 Microbiological Quality Assessment

Whey based fruit drink was analysed for aerobic bacteria and yeast and mould. Samples were plated every four days intervals for aerobic plate count (APC) and Yeast and mould count.

Aerobic plate counts

Take a sterile petridish and using a sterile pipette transfer 1-ml of the sample in to the dish. Repeat using the further dish if a duplicate is required. Labelling the plates as date of plating, ample name and time/code. About 15 ml of molten SPCA agar tempered to 45°C±1 into each petridish. The time elapsing between the preparation of the sample and the addition of the agar must not exceed 15 minutes.

Mix immediately after pouring into each petri dish by rotating the dish sufficiently to obtain evenly dispersed colonies after incubation. Allow the agar to solidify at room temperature. If spreading colonies are expected more dilution is preferred. Prepare blank control plates by pouring about 15 ml of molten SPCA agar into a petri dish.

Incubate all plates aerobically at 30°C±1 for 72± 3 hrs.

Yeast and mould plate count method

Two replicates of 1 ml of whey based fruit drink was transferred onto two sterile petri dishes. About 15 ml of potato dextrose agar at 45±1°C was poured into each petri dish followed by mixing the contents by rotating the closed petri dishes. The agar was than allowed to solidify at room temperature. This procedure was done under sterilized laminar flow cabinet.

The plates were then incubated in an inverted position aerobically at 25 ±1°C for5 days ±3 hours. The colonies were counted using a colony counter in subdue light and the results were expressed as "Yeast and Mould", colony forming units (C.F.U) per gram.

3.3 Raw Material Cost Analysis

The raw material cost was analysed for the finish product based on current price.

CHAPTER 4

4.0 Results and discussion.

4.1 Results

Results of the sensory evaluation test of selecting best percentage level of whey powder were discussed below.

4.1.1 Result of sensory evaluation

4.1.1.1 The effect of taste panel

The effect of the panel on the evaluation of quality parameters was not significant. So there was no any bias effect on the decisions made by the tasting panel. Also the panelist-to-panelist variation was not found in decision-making.

4.1.2.2 The effect of treatment on the thickness of the whey based fruit drink

The probability value (P=0.012) of the test is less than the minimum probability value (P=0.05) that is required for the test to be significant(Annexure II). There fore at east one treatment is significant with regard to thickness of fruit drink. The treatment number 4 (treatment code 404, 80% of whey powder) has gained the highest average rank (83.3). The highest estimated median has become under the category of "Like moderately" while other can be classified as "Neither like nor dislike".

Table 4.1 Effect of treatment on thickness

Sample	N	Median	Ave Rank	Z
122	25	6.000	57.4	-0.86
345	25	5.000	54.9	-1.25
404	25	7.000	83.3	3.14
586	25	5.000	51.2	-1.83
826	25	6.000	68.2	0.80

4.1.1.3 The effect of treatment on taste of the whey based fruit drink

The probability value (P=0.009) of the test is less than the minimum probability value (P=0.05) that is required for the test to be significant. There fore at least one treatment is significant with regard to taste of the fruit drink. The treatment number 4 (treatment code 404, 80% of whey powder) has gained the highest average rank (84.0). The highest estimated medians has come under the category of "Like moderately", while others can be classified as "Like slightly" or "Neither like nor dislike".

Table 4.2 Effect of treatment on taste

Factor	N	Median	Ave Rank	Z
122	25	6.000	62.8	-0.04
345	25	5.000	52.5	-1.63
404	25	7.000	84.0	3.24
586	25	5.000	50.5	-1.93
826	25	6.000	65.3	0.35

4.1.1.4 The effect of treatment on mouth feel of the whey based fruit drink.

The probability value (P=0.024) of the test is less than the minimum probability value (0.05) that is required for the test to be significant. There fore at least one treatment is significant with regard to mouth feel of the whey based fruit drink. The treatment number 4 (treatment code404, 80% of whey powder) has gained the highest average rank (81.0). The highest estimated median has come under the category of "Like moderately", while others can be classified as "Like slightly"

Table 4.3. Effect of treatment on mouth feel

Factor	N	Median	Ave Rank	Z
122	25	6.000	63.2	0.02
345	25	6.000	52.6	-1.60
404	25	7.000	81.0	2.77
586	25	5.000	51.0	-1.85
826	25	6.000	67.2	0.65

4.1.1.5 The effect of treatment on overall acceptability of the whey based fruit

The probability value (P=0.006) of the test is less than the minimum probability value (P=0.05) that is required for the test to be significant. There fore at least one treatment is significant with regard to overall acceptability the whey based fruit drink. The treatment number 4 (treatment 404, 80% of whey powder) has gained the highest average rank (81.1). The highest estimated median has come under the category of "Like moderately", while others can be classified as "like slightly" or "Neither like nor dislike".

Table 4.4: Effect of treatment on overall acceptability.

Factor	N	Median	Ave Rank	Z
122	25	6.000	62.1	-0.14
345	25	5.000	49.2	-2.13
404	25	7.000	81.1	2.79
586	25	5.000	50.4	-1.94
826	25	6.000	72.2	1.42

According to result of the organoleptic test (treatment code 404) sample was selected as the best sample. 80% of whey powder was included in that treatment. All the product developments, chemical Analysis, Microbiological Analysis and Self-life evaluation was done to the selected formulae.

4.1.2 The result of the most suitable stabilizer.

The RecodanRs with Seakem CM611 was not tolerated to low pH conditions. Coagulations were presented after heat treatment. So RacodanRs with Seakem CM611 was rejected. The sedimentations were not occurred with Carboxy methyl cellulose (C.M.C). So the most suitable stabilizer was C.M.C among these three stabilizers.

4.1.3 Finish product Analysis

Total solids, pH, Acidity and Brix was tested for the finish product.

Total solids - 13%

pH - 4.00

Acidity - 0.2%

Brix° - 12

4.1.4 Result of the Evaluation of product during storages

4.1.4.1 Physical changes during 4°C±1 storage

There was no gas formation, discolouration or mould growth observed in any of the samples after 40 days, storage at 4°C±1. There was no flavour deterioration during this period.

4.1.4.2 Physical changes during 15°C±1 storage

There was no gas formation discolouration or flavour deterioration in any of the samples after 40 days in 15°C±1 storage.

4.1.4.3 Physical changes during 25°C±1 storage

There was no gas formation discolouration or flavour deterioration in any of the samples after 40 days in 25°C±1 storage.

4.1.5 pH and Titrable acidity changes during storage

4.1.5.1 pH changes during storage

The probability value (P=0.36) of the test is higher than the minimum probability value (P=0.05) that is required for the test to be significant. Therefore no significant difference was found in pH throughout the storage.

Table 4.5. The pH changes during storage

Trt	(pH) Days after storage									
	4	8	12	16	20	24	28	32	36	40
4°C	4.08	4.11	4.17	4.11	4.16	4.17	4.18	4.16	4.17	4.18
15°C	4.10	4.12	4.14	4.18	4.13	4.11	4.16	4.16	4.16	4.16
25°C	4.16	4.24	4.26	4.15	4.13	4.16	4.19	4.20	4.16	4.14

The data which is represented in a box is the mean of three replicates.

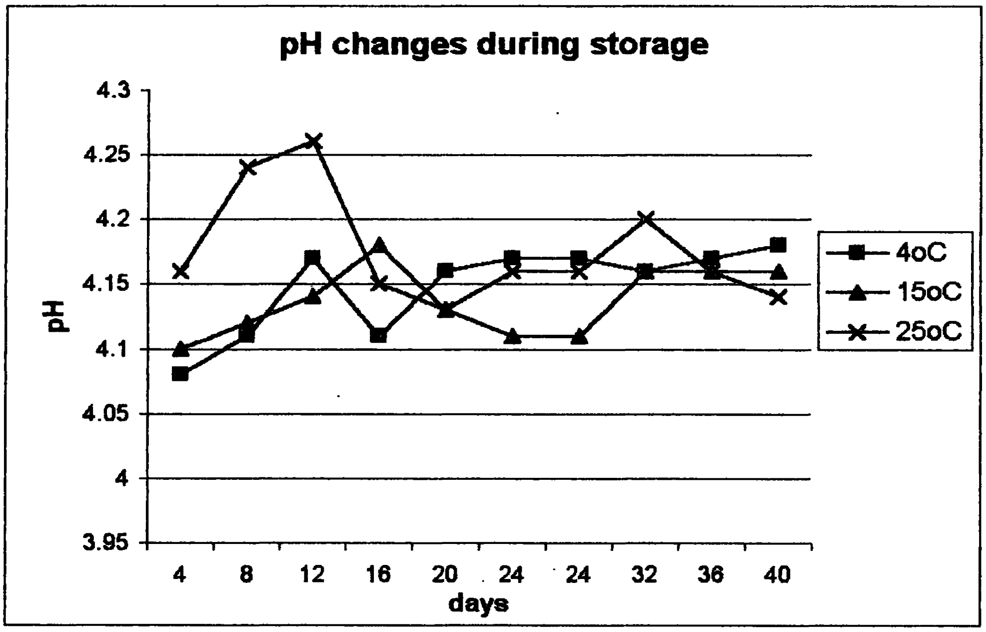


Figure: 4.1 pH changes during storage

4.1.5.2 Changes of acidity during storage

The probability value (P=0.37) of the test is higher the minimum probability value (0.05) that is required for the test to be significant. Therefore no significant difference was found in pH throughout the storage.

Table 4.6: Acidity changes during storage

Trt	(Acidity) Days after storage									
	4	**8**	**12**	**16**	**20**	**24**	**28**	**32**	**36**	**40**
4°C	0.23	0.20	0.22	0.20	0.20	0.22	0.21	0.20	0.19	0.19
15°C	0.19	0.20	0.22	0.19	0.20	0.18	0.21	0.21	0.10	0.19
25°C	0.20	0.20	0.23	0.22	0.23	0.23	0.22	0.20	0.21	0.22

The data which is represented in a box is the mean of three replicates.

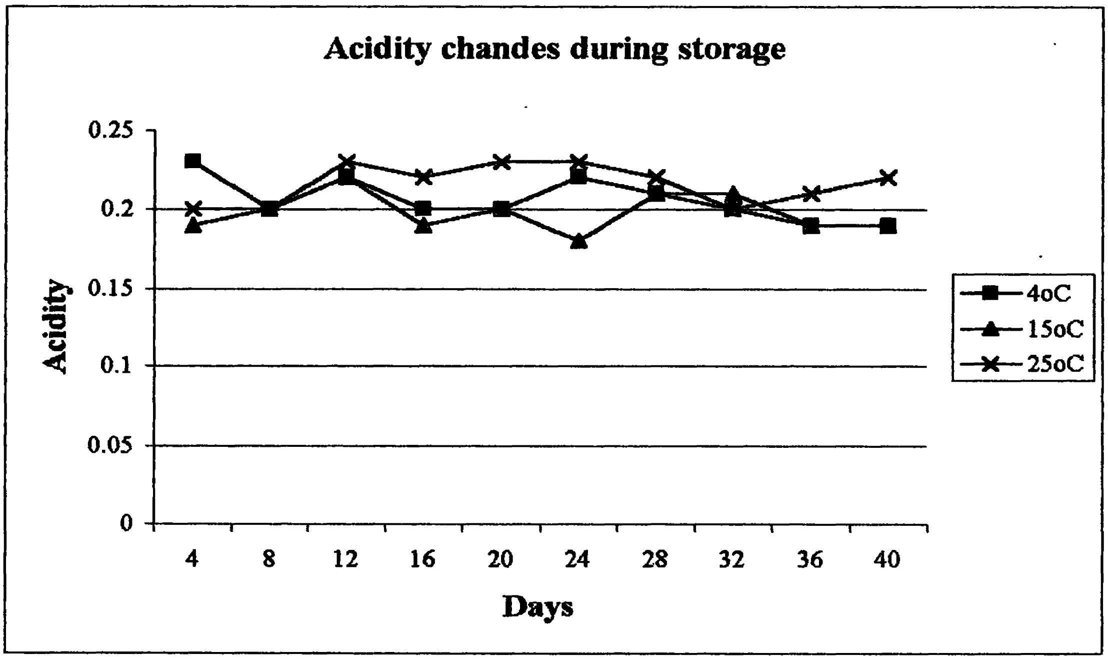


Figure: 4.2 Acidity changes during storage

4.1.6 Results of the Microbiological quality assessment

All the values of microbial counts are within the standard limits as per SLS 824:1989 as given in the table 4.3.

Table 4.7: Aerobic plate count, Yeast and mould count

Days	Yeast and moulds	Aerobic bacteria
0	No counts	No counts
4	No counts	No counts
8	No counts	No counts
12	No counts	No counts
16	No counts	No counts
20	No counts	No counts
24	No counts	No counts
28	No counts	No counts
32	No counts	No counts
36	No counts	No counts
40	No counts	No counts

4.1.7 Raw material cost analysis

Table 4.8 Raw material cost

Ingredient	Amount (g)	Cost of 1Kg of Ingredient (Rs)	Cost of 100 Kg of product (Rs)
Whey powder	12	100	120.00
Skim milk powder	3	300	90.00
Sugar	98	32	313.00
C.M.C	2	420	84.00
Orange juice	30	145	435.00
Flavours	0.05	4121	206.00
Colours	1.00	1000	1.60
Citric acid	10	70	7.00
		Total	**1257.30**

Raw material cost of 1Kg of product = 1257.30/100

= Rs. 12.57

Raw material cost of 200g of product = Rs. 2.50

4.2 Discussion

Whey is a water-based fluid that is produced as a by-product of cheese manufacturing. It contains milk components that are soluble in water, including many proteins, the sugar lactose and minerals. It can be converted in to high valuable product. Whey in the form of a beverage is, technologically, the simplest method for utilization in human food chain. Whey is used to produce drinks. Therefore whey based fruit drink was formulated and improved as a thirst quencher and refresher.

The accepted limit of whey powder to incorporate in fruit drink is between 50% to 100%, which was found by the preliminary trail and error test. There was low thickness and more watery appearance shown in the sample with 100% of whey powder. The sample with 100% skim milk powder appeared more milky and it was rejected as fruit drink.

Apart from the whey powder and skim milk powder the other main ingredient of whey based fruit drink is sugar, milk sugar (lactose), which is present in whey, is not as sweet as sugar that is naturally present in fruits, such as fructose and sucrose, and consequently it was necessary to sweeten whey based fruit drink. This can be accomplished by adding of sugars, syrups, honey or various low caloric sweeteners. Cane sugar was used as a sweetener in this study because it is the most available, low cost natural sweetener in the local market.

All of the common food acids can be used to produce sour taste, e.g. Citric acid, lactic acid... etc. In this test 10% citric acid solution was used to led down pH up to 3.8-4.2. A very fast and easy way to obtain a sour whey drink is adding food grade acids until the desired pH is reached.

Schwaband (1994) revealed that the addition of 50% citric acid solution in dosage of level 0.4% led to an end pH of 4.0-4.5. Protein sedimentation can be prevented by reducing pH to 4.0.Therefore addition of citric acid is a successful method to reduce pH in the whey based fruit drink. In general consumption of more than a small glass (100 ml-150 ml) of pure fruit juice required with effort due to its high acidity. Whey drinks, which have higher pH 3.8-4.2, are lighter in mouth feel and less astringent.

Fruit juice can be added to emphasize the health character of the product or to support the juicy impression. This whey based fruit drink was prepared by adding 3% of orange juice with 10.5° Brix, 10% of Total solid and 3.5-3.7 of pH . The orange juice made an additional nutrition and a taste to the whey based fruit drink. Studies of Touhy (1987) further shown that the flavours of whey are very compatible with citrus fruit juices, particularly with orange juice.

Colour of the product is an important quality attribute at the market as consumers buy with eyes. The greenish colour of whey and orange colour of juice was not much compatible for consumer attraction. Therefore food grade food colour were used to enhance the colour of the final product.

When considering the natural colour of the whey and orange juice it was not enough to satisfy customer a attractive colour to the product. So the food grade colours were used to make this whey based fruit drink.

A suitable stabilizer is an essential requirement of whey based fruit drink in ordor to reduce sedimentation. Pectin, Carboxy Methyl Cellulose (CMC) and RecodanRs with seakem CM611 were tested as stabilizers for the product. There were sedimentation occurred in the sample, which prepared with pectin, due to low pH and high teat treatment conditions. Stabilizing action of pectin was reduced. After heat treatment coagulation was observed in the sample, which was made with Recodan Rs and Seakem CM611 stabilizer. Recodan Rs and Seakem CM611 were not able tolerate low pH and high heat treatment during the processing. No sedimentation was observed in the samples prepared with CMC. CMC tolerates wide range of pH and high heat treatments. According to Kevin (1985) addition of stabilizers in whey based fruit drink is an essential to prevent the sedimentation.

Ultra High Temperature (UHT) treatment was used to preserve the whey based fruit drink. Kevin, (1985) revealed that the shelf life of pasteurized whey drink was 2-3 weeks at refrigeration temperature. But the product developed in this study obtained longer shelf life compare to Kevin, (1985) because of UHT treatment. Also product was able to survive at ambient temperature. The reason for the longer shelf life at ambient temperature is the ability of UHT treatment to kill all spore forming vegetative microorganisms. It was clear that vegetative cells were killed by pasteurization treatment in the studies of Kevin (1985), but remaining spore former limit the shelf life of the product up to 2-3 weeks.

Organoleptic evaluation was carried out with experienced panel for determine appropriate whey: skim milk powder ratio. Scores were obtained for thickness, taste, mouth feel and overall acceptability. Among five samples, whey based fruit drink with 80% powder achieved good rating for thickness, taste, and mouth feel. When comparing all five samples, the panelist preferred the 80% whey powder added drink.

The product was stored in three different temperatures as 4°C, 15°C and 25°C. No changes were observed in colour, odour and thickness over the 40 days of storage. No any sings were observed for microbial growth throughout the storage period. Colour odour and thickness of the product was preserved during the storage life due to UHT treatment, which destroyed all the vegetative and spores forming organisms in the product.

No significant different were found in pH and acidity through out the storage period. All the microbial actions were inhibited by UHT treatment. So pH and acidity changes were not presented.

The successfulness of this type of experiments mainly depends on having good sanitary condition from the raw material receiving up to product bottling. All the experiments were done under good manufacturing practices and all the critical points in manufacturing line were carried out at the laminar air floor.

The introduction to whey based fruit drink local market will offer consumers a totally new taste with significant health benefits, which can result in a more sophisticated image of whey drinks with excellent marketing opportunities.

CHAPTER 5

5.1 Conclusion

The possibility of utilizing whey powder for production of fruit drink has been feasible. The most acceptable percentage of whey powder was 80% from the total percentage of powder in production of whey based fruit drink. CMC was the most suitable stabilizer to prevent the sedimentation of this product.

The final product specifications are within prescribed standards with a fair storage life 40 days at $4^0C\pm1$, $15^0C\pm1$, $25^0C\pm1$ temperatures without any deterioration of quality parameters.

The raw material cost was Rs. 12.57 per 1 Kg of product. So the development of low cost whey based fruit drink has been feasible.

5.2 Recommendations and further studies.

1. Market research should be carried out for consumer acceptability of the product.
2. Shelf life studies should be carried out further more.
3. It is necessary to development of cost effective packaging material for this whey based fruit drink.

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Annexure I

Organoleptic Testing of whey based fruit drink

- This is a whey based fruit drink, which is to be used as a **thirst quencher and refresher**
- Please taste 4 samples of the drink and indicate your score against the sample code.
- The ratings for such samples are given in numeric values ranging from 9 (Like extremely) to 1 (Dislike extremely) as given below.

  Like extremely………………9
  Like very much………………8
  Like moderately………………7
  Like slightly…………………..6
  Neither likes nor dislikes……5
  Dislike slightly………………..4
  Dislike moderately…………..3
  Dislike very much……………2
  Dislike extremely……………1

Quality character	**Panel Score**				
	826	**404**	**345**	**122**	**586**
Thickness					
Taste					
Mouth feel					
Overall acceptability					

Comments……………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

Thank you.

Annexure II

Kruskal-Wallis Test

Kruskal-Wallis Test on Response

Thickness

Factor	N	Median	Ave Rank	Z
122	25	6.000	57.4	-0.86
345	25	5.000	54.9	-1.25
404	25	7.000	83.3	3.14
586	25	5.000	51.2	-1.83
826	25	6.000	68.2	0.80
Overall	125		63.0	

H = 12.91 DF = 4 P = 0.012
H = 13.35 DF = 4 P = 0.010 (adjusted for ties)

Kruskal-Wallis Test

Taste
Kruskal-Wallis Test on Response

Factor	N	Median	Ave Rank	Z
122	25	6.000	62.8	-0.04
345	25	5.000	52.5	-1.63
404	25	7.000	84.0	3.24
586	25	5.000	50.5	-1.93
826	25	6.000	65.3	0.35
Overall	125		63.0	

H = 13.58 DF = 4 P = 0.009
H = 14.03 DF = 4 P = 0.007 (adjusted for ties)

Kruskal-Wallis Test

Mouth feel
Kruskal-Wallis Test on Response

Factor	N	Median	Ave Rank	Z
122	25	6.000	63.2	0.02
345	25	6.000	52.6	-1.60
404	25	7.000	81.0	2.77
586	25	5.000	51.0	-1.85
826	25	6.000	67.2	0.65
Overall	125		63.0	

H = 11.25 DF = 4 P = 0.024
H = 11.60 DF = 4 P = 0.021 (adjusted for ties)

Kruskal-Wallis Test

overall acceptability
Kruskal-Wallis Test on Response

Factor	N	Median	Ave Rank	Z
122	25	6.000	62.1	-0.14
345	25	5.000	49.2	-2.13
404	25	7.000	81.1	2.79
586	25	5.000	50.4	-1.94
826	25	6.000	72.2	1.42
Overall	125		63.0	

H = 14.48 DF = 4 P = 0.006
H = 14.88 DF = 4 P = 0.005 (adjusted for ties)