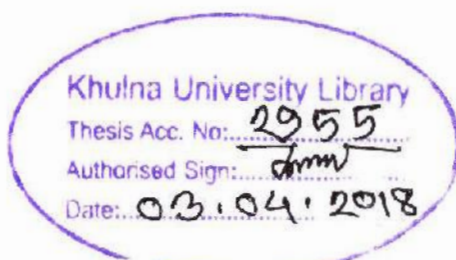


COMPARATIVE QUALITY STUDY OF SELECTED FULL CREAM POWDER MILK AVAILABLE IN BANGLADESH



**A THESIS
BY
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Examination Roll No. MS 070731
Session: 2006-2007**



SUBMITTED TO

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BIOTECHNOLOGY AND GENETIC ENGINEERING**

**BIOTECHNOLOGY AND GENETIC ENGINEERING DISCIPLINE
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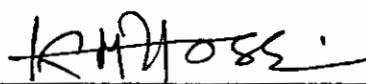
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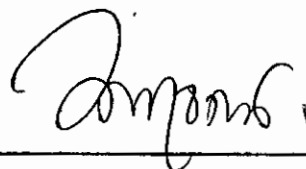
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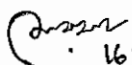
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DEDICATED
TO
MY ELDEST BROTHER

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**IN THE NAME OF ALLAH, THE ALMIGHTY, MOST GRACIOUS AND MOST
MERCIFUL, HE WHO OWNS ALL GRATITUDE AND PRAISES.**

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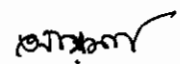
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The author

COMPARATIVE QUALITY STUDY OF SELECTED FULL CREAM POWDERED MILK AVAILABLE IN BANGLADESH

Declaration

This thesis reports the original research work of the author, except as otherwise stated. The material presented has not been submitted either in whole or in part for a degree from this or any other university. The findings of the research has not been/will not be published anywhere without the concurrence of the concerned supervisor/co-supervisor.

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ABSTRACT

Powder milk have high food value, good keeping quality, low microbial contamination and also available in the local market. An experiment was carried out to measure the physical, chemical and microbiological qualities of different brands (Milk Vita, Dano, Anchor, Diploma and Starship) of full cream powder milk available in the market of Bangladesh. Regarding physical tests (flavour, taste, appearance and specific gravity), no significant differences were found in the experimental samples. However, significant differences regarding colour and odour were found among the experimental brands. In chemical tests (fat, solids-non-fat, total solids, protein, lactose, ash, acidity and moisture content), the most important factor acidity % of the experimental selected brands viz. Milk Vita, Dano, Anchor, Diploma and Starship were 1.04 ± 0.008 , 1.07 ± 0.010 , 1.00 ± 0.007 , 1.09 ± 0.005 and 1.10 ± 0.004 respectively. The fat % were 26.36 ± 0.125 , 25.56 ± 0.375 , 26.125 ± 0.250 , 26.125 ± 0.250 and 26.00 ± 0.0479 respectively. The protein % were 26.87 ± 0.050 , 26.65 ± 0.289 , 26.25 ± 0.096 , 26.41 ± 0.250 and 26.93 ± 0.289 respectively. The ash % were 5.90 ± 0.285 , 6.15 ± 0.058 , 5.95 ± 0.850 , 6.00 ± 0.69 and 6.13 ± 0.082 respectively. The moisture % were 2.76 ± 0.096 , 3.69 ± 0.263 , 2.97 ± 0.096 , 3.88 ± 0.096 and 3.93 ± 0.096 respectively. The lactose % were 38.00 ± 0.521 , 38.50 ± 0.310 , 38.18 ± 0.208 , 38.23 ± 0.316 and 37.03 ± 0.035 respectively. The solid-non-fat % were 71.00 ± 0.252 , 71.30 ± 0.137 , 70.38 ± 0.452 , 69.64 ± 0.330 and $71.09 \pm 0.0.283$ respectively. The total solids % were 97.36 ± 0.36 , 96.86 ± 0.536 , 96.51 ± 0.287 , 95.77 ± 0.096 and 97.09 ± 0.085 respectively. There was no significance differences among fat, solids-non-fat, total solids, protein, lactose, ash, acidity and moisture content of the experimental samples. The average value of the experimental results of different parameters were within the acceptable range. The total viable bacteria counts were 400 ± 75.65 , 500 ± 58.75 , 500 ± 57.79 , 300 ± 81.65 and 500 ± 50.00 respectively and were within normal range. The differences were not statistically significant. The coliform bacteria count was nil. From the experimental results, it was observed that the quality of full cream powder milk of Milk Vita, Dano, Anchor, Diploma and Starship were within the acceptable range. Further study regarding quality control of other available powder milk in the market would be worthy to investigate.

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List of Abbreviations:

BAU = Bangladesh Agricultural University
DSL = Directorate of Livestock Services
TS = Total Solids
SNF = Solid-non-fat
Sp. Gr. = Specific Gravity
Vit. = Vitamin
Temp = Temperature
H = Hour
UHT = Ultra Heat Treatment
HTST = High Temperature Short Temperature
LTLT = Low Temperature Long Time
cfu = Colony Forming Unit
Av = Average
D = Day
Deg = Degree
L/D = Litre Per Day
e.g. = Example Given
Lab. = Laboratory
H₂SO₄ = Sulphuric Acid
Ca = calcium
NaOH = Sodium Hydroxide
ml = Milli Litre
No = Number
Dr. = Doctor
Et al. = Et Alia (associate)
Fig. = Figure
CRD = Completely Randomized Design
SED = Standard Deviation
viz. = Namely
vs = Versus
WHO = World Health Organization
FAO = Food and Agricultural Organization
NPU = Net Protein Utilization
Wt = Weight
X = Mean
% = Percentage
& = and
> = is more than
< = is less than
NS = Non significant
S = significant
°C = Degree Celsius
ANOVA = Analysis of Variance

CHAPTER 1

INTRODUCTION

INTRODUCTION

Milk is an almost complete and well balanced food from adolescent to adult. Its main constituents supply energy and building materials for young and are accompanied by various nutrients like minerals, vitamins and organic compounds important from nutritional point of view. Since all nutrients in milk are present either in the form of a solution, dispersion or colloidal system, the mixture is easily digestible (Van den Berg, 1988a).

Milk is understood to be the whole secreted product of female mammals, obtained from healthy animals through complete, uninterrupted milking and unmodified in its composition (Kurmann *et al.* 1997).

Milk is defined as the physiological secretion, practically free from colostrum, obtained by the complete milking of one or more healthy cows or buffaloes. Milk is one of few food stuffs consumed in its natural state. Milk contains about 85 different nutrients. It meets the nutritional requirement of body better than any other single food. It is therefore called the most nearly "complete food" or "ideal food" (Lampert, 1970). It contains six essential elements such as carbohydrate, fat, protein, minerals, vitamins and water.

Bangladesh has an acute shortage of high quality fluid milk. Availability of milk is only 13.9 ml per head per day whereas we need 250 ml milk per head per day (Ali, 1999). Since the production rate of liquid milk is insufficient to meet the demand of our increasing population, so we have to import powder milk which have high food value, good keeping quality, low microbial contamination and also available in the local market.

Some unconscious milk producers might add different chemicals to increase preservability of milk and profit oriented dairy farms might have mastered the tricks of milk adulteration. The huge profit margins by sale of adulterated milk have made this happen. The various harmful chemicals used to adulterate milk could prove to be serious health hazard to milk consumers. These adulterating components of milk might be carcinogenic for human beings and can lead to gradual impairment of human body. The feeding of adulterated milk may also lead to both hepatotoxicity and nephrotoxicity in

human beings. Also children could not digest such adulterants which might lead to serious digestive problems (Yasmin, 2007).

The nutrient level of raw milk and the method of processing dictate the level of vitamin retained. Vitamin A is retained in good proportions in drum-dried and spray-dried milk. Vacuum packaged dry milk can be stored with good retention of vitamin A (Norman and James, 2004).

Actually, in our country, milk powder is used for many purposes including making ice cream, curd, custard, pudding and other milk-based food preparation irrespective of its use in normal liquid milk preparation and even for the preparation of infant food in some instance (<http://clk.atdmt.com>).

The biological value of the dry milk protein is 89; milk protein is highly digestible. All of the essential amino acids are contained in dry milks. Analysis of spray dry processed milk indicated a slight destruction of lysine and no difference in its availability compared to fresh milk (Mauron *et al.* 1955). The oxidation of fat in milk is greater at high temperatures than of low temperatures of dehydration.

Powder milk is the product obtained by the removal of water from milk, partly skimmed milk or skimmed milk (definition code of principles FAO/WHO-1973). The compositional quality factors are set as follows:

Composition of various categories of powder milk

Product	Milk fat content (%)	Water content (max %)
Whole milk powder	Min 26.0, less than 40.0	5
Partly skimmed milk powder	More than 1.5, less than 26.0	5
skimmed milk powder	Max 1.5	5

(Source: FAO/WHO, 1973).

According to United States Food administration, "Milk is one of the important foods sources of the human race posses. For the proper nourishment of the child it is absolutely necessary and its use should be kept up in the diet as long as possible. Not only does it

contain the entire essential food elements in the most available form for ready digestion, but the scientific discoveries have shown it to be especially rich in certain indispensable properties that alone render growth possible". By good quality was understood that "it should be free from all pathogenic microorganisms and any other harmful substances, clean free from extraneous materials such as dust, dirt, soil, manure, etc., normal in composition, of good flavor, low total microbial count, low in acidity and adequate in keeping quality" (Foster *et. al.*, 1958).

Bangladesh Milk Producers' Co-operative Union Limited (Milk Vita) is the only Co-operative Union Ltd, which produces powder milk in Bangladesh. Other different companies are importing powder milk from different countries to meet up the existing demand of milk.

Microorganisms are widely distributed throughout the nature and foodstuffs at one time or another are in contact with soil and dust. Method of control is in the restriction of moisture for growth. Bacteria and yeasts require higher moisture levels, usually over 30%. Molds can grow with as little as 12% moisture, and some are known to grow with less than 5% moisture (Norman and James, 2004).

The quality of dried milk product greatly depends upon the microorganisms of liquid milk, while milk has a high nutritive value, not only for the newborn mammal and for the human consumer, but also for microbes (Ahmed and Anwar (2006).

A variety of diseases are potentially transmissible through milk. Milk may be contaminated through infected cow having tuberculosis, brucellosis and mastitis and also from human carrier having typhoid fever, diphtheria, dysentery and scarlet fever. Dairy cattle and their farm's environments contain *Listeria*, *Salmonella* and pathogenic *Eschericia coli*. Consumption of raw or inadequately pasteurized milk also associated with toxin-producing *E. coli*, *Salmonella* and *Listeria monocytogens*. *Staphylococcus aureus* can also present in the cows udder and teats and consequently contaminate the milk. The aerobic plate counts ranged from 1.4×10^1 - 4.4×10^4 cfu/g. According to the Codex Alimentarius Commission guideline, the dried milk powder should contain less than 5.0×10^4 cfu/g. According to the specification given by the ICMSF, it should be less

than 3.0×10^4 cfu/g. Coliform organisms in dried milk powder might die out during processing and storage (Ahmed and Anwar (2006).

It is essential to know the quality of powder milk existing in the market. It is obviously imperative to have knowledge about the physio-chemical and microbial implications associated with its consumption. Consumers do not have any idea about the quality of powder milk what they are purchasing from the market. For these reasons the present study was designed to evaluate the physical, chemical, and microbiological qualities of selected brands of powder milk with the following objectives:

- i. To determine the physical and microbiological qualities of different selected brands of full cream powder milk available in the market.
- ii. To determine the chemical quality viz. fat, acidity, protein, lactose, ash, total solids, solids-non-fat and moisture content of different brands of selected full cream powder milk.
- iii. To build up awareness among consumers about the quality of full cream powder milk available in the market in Bangladesh.

CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Review of Previous Research Findings

Different kinds of research works have been done by different scientists on adulteration of milk, along with its physical, chemical and microbiological qualities. Some of the important research findings are reviewed in this section.

Ahmed and Anwar (2006) studied on the microbiological status of dried milk samples belonging to eleven different companies. With few exceptions, the microbial counts of the milk samples were within the acceptable limits as specified by international authorities. Aerobic plate counts ranged from 1.4×10^1 - 4.4×10^4 cfu/g and the number of *Staphylococcus* varied from 6.0×10^1 - 8.2×10^2 cfu/g. Presence of *Staphylococcus* in most of the samples indicates post-processing contamination of the milk. Coliform organisms and *Salmonella* were not detected from any of the samples tested. Yeasts or molds were found in the samples of four manufacturers but their counts were very low. The author claimed that the international agencies have not fixed any limit for *Staphylococcus* count in dry milk, the results of the present study indicate that powder milk products were of good quality from microbiological point of view.

Macedo et al. (2005) studied on comparative results on powder milk storage quality, obtained from analytical methods. Protein content was determined using Kjeldahl and colorimetric with biuret reagent at 540 nm and integral quality by thermogravimetric and biological methods. The method was developed for the protein separation of powder milk. Powder milk was submitted to degradation processes at 45, 60 and 80°C for 20 days. The results indicated that protein content values were inconsistent by Kjeldahl and colorimetric methods and biological tests were compared. There is evidence of thermal decomposition of powder milk as detected by biological and thermogravimetric methods.

Zhou-Hong et al. (2000) studied about cholesterol, beta-sitosterol and campesterol in powder milk by GC. The minimum detectable value of cholesterol was 3.23×10^{-9} g, campesterol was 5.41×10^{-9} g and beta sitosterol was 8.20×10^{-9} g.

Amrita Kadian *et al.* (1998) carried out an experiment on bacteriological and sensory qualities of milk powders manufactured in Haryana. On average the colony forming unit (cfu), Coliform count and staphylococci count (log/g) of various brands of partly skimmed powder milk were 4.587 ± 0.068 , 1.682 ± 0.18 and 3.647 ± 0.047 and that of skimmed powder milk were 4.576 ± 0.084 , 1.848 ± 0.18 and 3.696 ± 0.038 respectively. Only 61.87 and 54.74% of samples of partly skimmed powder milk and 61.06 and 44.4% of skimmed powder milk meet the prescribed PFA standards with regard to colony forming unit (cfu) and Coliform count respectively. As per bureau of Indian Standards, the organoleptic quality of majority of samples of powder was graded good (80-89), while three brands of partly skimmed powder milk were graded fair (60-79).

Rahman (1995) conducted an experiment on physical and chemical qualities of milk collected from Bhghabari dairy plant, Takerhat pasteurization plant, Manikganj Chilling centre and Tangail chilling centre. He reported that the specific gravity, fat, solids-not-fat and total solids content of milk were 1.0274 ± 0.0006 , 4.95 ± 0.24 14%, $7.69 \pm 0.2799\%$ to $7.20 \pm 0.3293\%$, $11.48 \pm 0.5769\%$ for milk collected from Manikganj chilling centre, 1.0229 ± 0.0012 , $4.10 \pm 2759\%$, $6.67 \pm 0.3282\%$, 10.78 ± 0.5 17% for milk collected from Tangail chilling centre, 1.0246 ± 0.0004 , $3.68 \pm 0.00763\%$, $7.04 \pm 0.1064\%$ and $10.72 \pm 0.133\%$ for milk collected from Takerhat, Pasteuzation plant respectively.

Kumar and Murthy (1994) studied on storage life of buffalo whole powder milk packed in HDPE bags. Change in pH, viscosity and stability of reconstituted milk in relation to age and Organoleptic quality, storage at 20° / 60-75% RH. After 12 months storage, there was a gradual decline of 0.08-0.12 units in pH. A steady decline of 14-17 min in heat stability and an average increase of 0.24 CP units in viscosity. It is concluded that changes in heat could serve as an index of age of the DWM (dried whole milk) and that an abrupt and substantial change in pH, heat coagulation time and viscosity could serve as an index of deterioration in quality.

Salam (1993) studied the physical, chemical and biological qualities of milk produced in Bagabarighat milk shed area of Milk vita and reported that the means and standard deviations of specific gravity and fat content of milk produced by Bagabarighat milk shed area were 1.02757 ± 0.001 and $5.096 \pm 0.389\%$ respectively.

Lee *et al.* (1993) carried out an experiment to judge the effect of drying on physiological properties of milk powder. Results are presented for drum, spray and freeze dried whole milks and spray dried skim and modified milks. Hausnce ratio, angle of response and compressibility of spray dried skim milk (powder) were 1.127, 32.5° and 0.029 respectively, indicating that skim powder milk had free following characteristics. Compressibility of drum dried whole powder milk decreased with decreased moisture contents. Drum dried powders were also characterized by high bulk density (0.382 g/cm^3). Compressibility of dried milk granules was lower than that of dried milk powders. Spray dried powder milk had higher solidity than freeze or drum dried milk powders. Drum dried powder milk particles had an irregular shape.

Uplalkash *et al.* (1992) conducted a survey of bacteriological and biochemical quality of sterilized flavored milk. They found that sterilized flavored milk sample showed a maximum spore count of 3 per 10 ml initially. There was hardly any variation in number in replicate samples during storage at 37°C . Acidity increased steadily but not very substantially throughout incubation period of 9-13 weeks. The extent of proteolysis was highest in source no. 1 but the rate of proteolysis was maximum in sources of other sample especially between 10 and 11 weeks of storage.

Kneifel (1990) studied on storage ability of full cream powder milk with special regard vitamin content. Physicochemical parameters and results from provocation tests, spray dried whole milk was stored in miniaturized bags and variation of certain physicochemical parameters during long term storage, together with vitamin stability influenced by provocation trials (45°C , 4wk), was studied of storage of powder for 1 year at 20°C and 30°C resulted in moisture content increased by 24.5% and pH decreased by 0.06 units. Hygroscopically and insolubility index remained unchanged. Non-protein nitrogen increased

by 60%, heat stability decreased and HMP values only increased slightly under these conditions. From the provocation test series at 45°C, thiamin, riboflavin, pyridoxine rather stable, cobalamin, pantothenic acid retinol moderately stable, folic acid, ritamine non stable.

Arora (1989) studied on the quality of skim powder milk manufactured in India. Mean chemical composition of 52 spray-dried (5 bands) and 20 rolled-dried (2 bands) samples of dried skim milk respectively was as follows: Moisture %, 3.88 and 5.87, fat % 1.10 and 1.19, lactic acid % 1.19 and 1.38, ash % 7.53 and 7.49, and solubility index (ml) 0.23 and 6.97, coliforms were present in 2 of 4 bands tested at levels of <11 0/g and total bacterial counts ranged from 2000 to 160,000/g in spray dried and 1350 to 11800/g in rolled-dried samples respectively that failed to attain the 151 (Indian standard institute) specification was 12 and 17 for moisture, 7 and 4 for fat, 13 and 5 for acidity, 10 and 4 for total count and 1 and 1 for coliform count.

Touhji (1989) studied on some physical properties of milk powder. The following data for some physical properties of regular and instantized dried skim milk (DSM), dried whole milk (DWM) are presented. Aerated bulk density ranged from 0.30-0.62g/cm³, compared with the range 0.44- 0.85 g/cm³ for packed bulk density and compressibility range from 32-40%. Mean particle size (medium value of cumulative distribution) ranged from 85 m for regular DSM to 230-260µm for FFDM. DSM was more dispersible in air (18-20%) than the fat containing powders (7-11). The angle of response ranged from 33-38°. For DSM to 40-58° for the fat containing powders.

Griffiths et al. (1988) carried out an experiment on the quality of skim powder milk produced from raw milk stored at 2°C for 24 and 7 hours respectively had the following mean bacterial counts: mesiphilic 5600 and 1200/ml, thedmoduric 3300 and 1000/ml, spore 2700 and 200/ml, and thermophilic 35 and 79/ml. Spore counts of dried skim milk were correlated ($r = 0.71$, $p < 0.01$) with those of raw milk for up to 3 day at 2°C had no adverse effect on physical and chemical properties or on heat stability of the dried milk when reconstituted to 9 and 22% TS.

Sarma and Tandon (1987) studied the effect of storage on nitrogen distribution in skim milk powders. When spray dried or rolls dried skim milk was stored for 12 months at 5°C, total N decreased, non-protein N, non-casein and protease-peptone-N increased; the changes were more significant on storage at 37°C.

Nakazawa (1987) studied on the detection of adulteration of dried skim milk with sugar and minerals. Analysis of sugar by GLC detected sugars than lactose in some samples of dried skim milk made in Japan. Analysis by AAS after ashing and dissolving in HCl showed that in some cases total Na, K and Ca contents were outside the range of 12.2-14.1, 17.5-20.5 and 8.2-14.0 g/kg and the relative proportion of 100:140:70 taken as normal. Contents of soluble Ca, K and Na in the sample. Samples were also sometimes outside the normal ranges of 6.3-81, 19.5-20.5 and 5.4-12.7 mg/kg.

Sayem (1986) reported that approximate cholesterol content per 100g of milk, meat, calf liver, whole egg and egg yolk is 12mg, 101mg, 260 mg, 500mg and 1500mg respectively. It appears that milk contains the minimum amount of cholesterol than other food consumed daily. Therefore, it is not fair to blame milk for heart disease. In addition, milk also contains Vitamin-F, which cures heart disease.

Ghodeker *et al* (1985) demonstrated that of (i) 125 spray dried milk, (ii) 54 roller dried milk and (iii) 38 infant formula samples from 10 factories, 3, 6 and 13 respectively contained > 1 coliform/g and 25, 10 and 5 contained > 90 coliform/g. Sixty five of 242 isolates were identified as *Escherichia coli*, distribution of *E. coli* in (i), (ii) and (iii) respectively was 57, 37 and 6, *E. coli* was not detected in (i) and (ii) samples from 3 factories of in (iii) samples from 7 factories when *E. coli* from 1 or 2 samples from each factory were inoculated into 3 and 7 isolates were lethal to all 3 mice with 24 to 38h. All 12 pathogenic strains survived heating at 63°C for 30 minutes. Survival rate of Coliform at room temperature in (i) was 10% after 3 months in 33.3% of samples, but none survived for 6 months. Coliform were able to grow in reconstituted infant formulas from > 10ml initially to 25000 and 20500/ml within 8 h at 45 and 37°C respectively, but did not show any increase in numbers for up to 12 h at 7-10°C.

Driscoll *et al* (1985) studied on sensory quality of nonfat dry milk after long term storage. Dried skim milk was stored under various conditions to determine the effects of temperature, packing, atmospheric gases and form of milk. Dried skim milk was significantly affected by storage temperature during long term storage, when held at 32°C for 6 months, it began to develop off flavours and by 24 months was considered unacceptable by the panelists. Storage at 10°C resulted in minimum flavour changes after 52 months. After 4 years storage, dried skim milk samples stored in polybags were statistically less acceptable ($P < 0.01$) than samples stored in cans. The form of milk (instant or regular) did not affect the length of time dried skim milk could be stored. Unacceptability of samples was due to an oxidized/stale flavour.

Ito (1982) worked on thermal conductivity of dried milks. Thermal conductivity (λ) of 4 dried milks increased as heating temperature and moisture content increased. For dried fat enriched milk, λ decreased when heating temperature exceeded 55°C, due to the liquefaction of the fat. Ranges of λ for dried skim milk (moisture 2.32-7.46%), dried whole milk (moisture 2.36-7.55%) and dried fat enriched milk (moisture 0.96-4.20%) each heated at 3-65°C, were 0.207-0.289, 0.245-0.348 and 0.220-0.260 Kcal/m.h. deg C. Conductivity also increased as bulk density (D) increased. For dried skim milk, dried whole milk and 2- dried fat enriched milk, respectively the equations relating λ (Kcal/m.h. deg C) and D (g/cm^3) were $\lambda = 0.168 + 0.662D$, $\lambda = 0.215 + 0.517D$, $\lambda = 0.074 + 2.03D$ and $\lambda = 0.065 + 1.88D$, with D in the ranges 0.610-0.757, 0.480-0.700, 0.45-0.546 and 0.450-0.598 respectively.

Matic (1979) carried out an experiment on the nutritive value of reconstituted dried milk. Twenty samples each of (i) whole and (ii) skim dried milk produced in Yugoslav dairy factories were examined and found that (i) and (ii) solubility, 92.82 ± 0.330 and $91.17 \pm 0.149\%$; lactose content 4.91 ± 0.047 and 5.52 ± 0.036 and fat content 2.90 ± 0.048 and 0.58 ± 0.047 . The fat contents of the dried milks were 23.4 ± 0.385 and $6.4 \pm 0.523\%$.

Nikodemusz (1979) studied the microflora in powder milk and baby food in powdered form. Five hundred and eighteen dried milk samples were examined over a 3 year period. Total

bacterial count/g in 436 samples (84.1%) was $< 10^4$, in 77 samples $> 10^4$ and only in 5 samples $> 10^5$, consisting lactobacilli, clostridia, staphylococci and moulds. Results for 935 samples of infant food containing dried milk showed that 76.1% had a total bacteria count of $< 10^4$ /g and 64.4% contained $< 10^3$ aerobic spore forming bacteria/g. Micrococci were identified in only 17%, bacillus species in 70%, moulds in 2%, clostridia and *Micrococcus caseolyticus* each in 10% of samples. The authors suggested bacteriological limits as follows: no pathogenic bacteria (*Salmonella*, *shigella*, *e.coli*, serotypes) in 25g; no enterobacteria (*e.coli*; *proteus* species and other Coliform), *Salmonella*, *shigella*, *psedomonus* species, enteric, streptococci or pathogenic staphylococci in 0.1g; aerobic spore forming bacteria < 1000 /g; moulds < 100 /g; clostridia $< 5\%$, other bacterial count $> 50,000$ /g.

Krag (1978) carried out an experiment on rate of hydration of lecithinated dried whole milk, 0.5 g dried milk was spread on 50 ml water at 20°C in a solubility tube, inverted 4 times and centrifuged within 30s at $174\times g$ for 5 minutes. Rate of hydration induce is defined as $12 \times$ (ml sediment) solubility index, it is normally 8-13 but indexes < 4 are good, 4-8 fair and $>$ poor.

Switka (1978) carried out an experiment on effects on storage conditions on the development of the Maillard reaction in dried skim milk. Available lysine content in dried milk was reduced by 12,23 and 49% respectively after 24 wk storage at 4,20 or 37°C and 95% RH, equivalent changes were found in hydroxymethylfurfural, Ferricyanide reducing power and casino polymers of mol. Wt > 2000000 . There was an induction period before the samples began to show detectable colour changes.

Jensen and Hasen (1978) conducted an experiment on the influence of packing and storage temperatures on the reconstitutability of instant whole milk powder. Reconstitutability, estimated from measurements of wettability, dispensability and solubility index, was best when the fat and lecithin treated dried whole milk was packed at temperature below the m.p. of the fat. There was little or no reduction in wettability after storage for up to 12 months at 13°C .

Valent (1978) studied on changes in some quality characteristics of dried milk in relation to storage duration and temperature. Three samples of dried whole milk produced during April were examined directly after manufacture, and 200g portions were stored in polythene bag at approx. 20°C and 60-65% RH or at 37°C and 30% RH and examined after storage for 2, 4, 6, 7 and 9 months. Contents of moisture and free fat, titrable acidity and thiobarbituric and benzidine values were determined, and correlations, between the characteristics measured were calculated. During storage at 20°C, free fat content increased from 34.6-36.6 to 34.8-38.6%, the thiobarbituric increased from 34.7-51.7 to 68.8-75.2. Corresponding final values for samples stored at 37°C were 36.2-38.9%, 26.1-31.3. Moisture content of samples was within 1.5-3.5% and the titrable acidity remained virtually unchanged. Contents of moisture and free fat were strongly correlated and thiobarbituric and benzidine values were strongly correlated with free fat contents and duration and temperature of storage.

Baldwin (1978) studied on the appearance of whole powder milk as related to physical properties and found that a critical visual appraisal of the appearance of a dried whole milk from a freshly opened pack can provide a useful evaluation of its quality. Such properties as granularity, cohesiveness and lumpiness correlate closely with quantitative measurements. Such as bulk density, particle size distribution, particle density and percentage of free fat.

Tran-The-Truyen (1977) studied on Investigation of some factors affecting the free fat content and solubility of dried milk. Experiments with 3 samples of dried whole milk of Hungarian, East German and Czechoslovak origin stored at various temperature (7, 20 and 32°C) and in air of various RH values (40, 60 and 80%) showed that at higher RH values and at higher temperature significantly increased the free fat content and decreased the solubility of dried whole milk.

Luck *et al.* (1976) carried out an experiment on a survey of powder milk for aflatoxin content. Aflatoxin M was determined in 56 samples of dried skim milk and dried whole milk, from 6 different producers (3 of which were at monthly intervals over a year) using the method of purchase and steven. No. of aflatoxin were detected in any of the samples (detection limits were 8 and 1 µg/kg for aflatoxin B1 and M1 respectively).

Pijanowski *et al.* (1975) conducted an experiment A selective chemical analysis of whole fresh powder milk and its technological interpretation. Analysis of 24 samples of fresh spray dried whole milk from polish factories gave the following average values moisture 2.74%, peroxides 4.75 mg O/kg fat, titrable acidity, of reconstituted milk, 6.53 deg SH, NH_3 1.74 mg/l. reconstituted milk, lactic acid/lactates 141 mg/100g SNF, hydroxymethylfurfural 5.27 mg/l. reconstituted milk(2.78-7.57); free fat, 22.5% (7.8-35.2); and unsaturated whey protein, 1.61 mg N/g considerable variation was found within some factory.

Byron *et al.* (1974) found the average gross composition of milk as follows:

Composition	Percentage
Water	87.20
Dry matter	12.80
Fat	3.70
Protein Lactose	3.50
Ash	0.70

Voss and Schmanke (1974) studied on the rennetability of dried skim milks. Evaluations of rennetability and curd firmness were best obtained by the use of the lactodynamograph of 40 spray-dried skim milks thus tested, rennetability was found to be good, satisfactory and unsatisfactory respectively in 18, 34 and 48% and curd firmness in 21, 26 and 53% of the samples, corresponding values found for 46 roller dried skim milks were 4, 17 and 79% and 0, 6 and 94% respectively.

Moor and Hendrickx (1969) studied on the determination of moisture in spray roller dried whole and skim milk and spray and roller dried whey powder by the Karl Fischer titration method. From these experiments, the following means of the SD for individual powders were obtained: spray dried whole milk 0.026 and 0.033%; spray dried skim milk, 0.026 and 0.040%, roller dried whole milk, 0.030 and 0.49%, roller dried skim milk, 0.36 and 0.044%, spray dried whey, 0.032 and 0.47%, roller dried whey, 0.037 and 0.033%. It is concluded that the Karl Fischer titration method is sufficiently accurate and reproducible to be used if serial analyses are made.

Hendrickx *et al.* (1969) studied on determination of moisture spray dried skim powder milk by 4 methods. The following 4 methods of determining moisture in spray dried skim milk were compared: (i) the karl fischer titration method (ii) the toluene distillation method (iii) the vaccum drying method at 75°C and 70mm Hg. By each of these methods the water content of 10 different samples was determined in quadruplicate. (i) give the highest moisture Content (3.99-9.77%) followed by (ii) (3.95-9.26) (iii) (3.66-8.38%) and (iv) (3.44-7.93). The ranges of the SD of the samples were: (i) 0.010-0.039% moisture (ii) 0.010-0.092% (iii) 0.010-0.037% and (iv) 0.010-0.047%. The means of these SD were respectively 0.026, 0.056, 0.024 and 0.026%. An analysis of variance proved the difference between the 4 methods as highly significant.

Koralezuk *et al.* (1968) carried out an experiment on chemical changes in stored spray dried whole milk. From each of 2 batches of ½ kg polythene bag of spray dried whole milk from 1 factory, 20 bag of spray dried whole milk from 1 factory, 20 bags were analyzed 57, 96, 144, 143 and 306 day after manufacture, from the pther batch 65, 86, 114 and 297 days after manufacture full results are prwsented graphically: they are similar for both batches. The initial value and final values after storage at 20°C and 37°C (given for 1st batch only) were respectively: moisture, 1.78, 3.00 and 2.43% solubility 99.7, 94.6 and 88.3%, protein by final titration, 28.8, 23.3 and 20.5% ascorbic acid, 103, 30 and 2 mg/kg, dedhydroascorbic acid 12, 2.4 and 6.1 mg/kg, sugar reductones (as ascorbic acid) 27.2, 62.3 and 35.6 mg/kg; protein reducing substance 6.92, 25.4 and 21.2 mg K₄Fe(CN)₆/g total hydroxymethylfurfural, 1.94, 5.69 and 81μ moles/l reconstituted milk free hydroxymethylfurfural 0.81, 4.60 and 4.22 μ moles/ l, peroxides, 503, 118 and 160 mg/kg fat, acidity of fat, 1.84, 2.21 and 2.66 ml N NaOH/ 100g.

Hejl *et al.* (1968) carried out an experiment on methods for the determination of physical properties of dried milks. Several physical properties are given for (i) 1 sample of spray dried whole milk, (ii) 2 samples of spray dried skim milk, (iii) 1 sample of half cream. Spray dried milk; the powders represented 5 different driers. For one (i) the bulk density was 0.56-0.65 g/cm³, particle density was 1.0-1.26 g/cm³ and the air occluded in the particles was 3.4-24.8 cm³/100g. For two (ii) the corresponding values were: 0.58 and 0.66 g/cm³, 0.93 and 1.05

g/cm³, 30.8 and 44.1 cm³/100g. The particle size distribution is given for two samples of dried whole milk.

Erbersdobler (1968) conducted an experiment on quality evaluation of dried skim milk. 2 batches of roller dried skim milk were produced from 1 bulk of raw skim milk; (i) at a stream pressure of 1.9-2.1 atm and rev/ mm, and (ii) at 32. atm and 24 rev/mm. For most of the 17 amino acids measured difference in content between the normal (i) and the scorched (ii) products were <5%, greater differences (g/16gN) were found for lysine (9.4 and 6.7), available lysine (6.9 and 4.2), cystine (1.1 and 0.9), histidine (3.2 and 2.8) and methionine (2.9 and 2.7). For raw skim milk and for precondensed and spray dried skim milk and precondensed and roller dried skim milk made from it, the values for lysine and available lysine were respectively: 9.45 and 7.4, 0.3 and 7.3; 9.1 and 7.15; 8.35 and 6.7 g/16gN.

Burbianka et al (1967) proposed the bacteriological evaluation of dried milk of 1129 samples of dried milk (A) 7.2% and (B) 5.1% did not satisfy the specification of the polish standard PN-59-A-86024 which described that dried milk for infant feeding should not contain >50,000 organisms/g. The standards also specify that (i) no Coliform should be detected in 0.1g and (ii) no enterococci in 0.01g and (iii) 99 colonies of anaerobic spore-formers should be detected in log. A total 7.8% of (A) and 1.3% of (B) did not satisfy specification (ii) but (iii) was satisfied throughout but doubt was expressed about the reliability of the test. Three hundred and thirty two samples of (B) were examined for *B. cereus*. In 71.3% of the samples none was detected in 0.1g of the milk, (1-50 colonies in 11.7% and 50-100 in 7.5%). Coliform were detected in three of all samples at titres 1:10 and 1:100 and staphylococci in one (1) sample. Pathogenic staphylococci and salmonella were not found.

Forsen and Kyti (1966) worked on bacteriological quality of dried milk and its determination. Bacterial counts were determined in 29 samples of dried milk according to the methods of American Dry Milk Institute (ADMI) and the International Dairy Federation. The former method gave distinctly lower counts than the latter. Differences were in the range of 0.14-80.32%. A bacterial count of 43.000/g was considered the maximum permissible.

Torre (1962) carried out an experiment on the of reconstituted dried skim milk. The average total and thermophilic bacterial counts for 30 samples of reconstituted dried skim milk were 354 and 72 organisms/ml respectively. Coliform was absent in 15 ml. Data were presented indicating the necessity of controlling the condition of reconstitution and storage temperature to reduce contamination and determination of the bacteriological quality of reconstituted dried milk.

Judkins and Keener (1960) observed the normal taste, color and flavor of milk produced under sanitary condition. They found that the normal taste of milk was slightly sweet, flavor was mild aromatic and color of milk was yellowish white. The sweet taste comes from the lactose and flavor mainly comes the butter fat. The color of milk comes generally from the vitamin content of milk.

Judkins and Keener (1960) reported that the breed of cow and the feed had an influence on color of milk. They observed that the color of milk from Guemsey and Jersey was yellowish and that of the milk from Holstein and Ayrshire was whitish.

It is obviously imperative to have knowledge about the physio-chemical and microbial implications associated with its consumption. The various harmful chemicals used to adulterate milk could prove to be serious health hazard to milk consumers. These adulterating components of milk might be carcinogenic for human beings and can lead to gradual impairment of human body. The feeding of adulterated milk may also lead to both hepatotoxicity and nephrotoxicity in human beings. The production rate of liquid milk is insufficient to meet the demand of our increasing population, so we have to import powder milk which have high food value, good keeping quality, low microbial contamination and also available in the local market.

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

This study was conducted in the Quality Control Laboratory of Bangladesh Milk Producers' Co-operative Union Limited (Milk Vita) at Mirpur of Dhaka, Bangladesh.

3.1 Sample Collection

To perform the study, samples from several brands of commercial full cream powder milk produced by Milk Vita, Dano, Anchor, Diploma and Starship were collected from different retail shops during the experiment.

3.2 Sampling

The sample collecting package was thoroughly shaken without being opened and later fixed in upright position. Taking all aseptic measures, packet was opened for obtaining the samples. An amount of approximately 120 g of powdered milk samples were taken out using a dry, sterile stainless steel spoons and spatulas. Samples were obtained from different depths. Collected samples were kept in a sterile glass jar.

3.2.1 Dilution of powder milk samples

Twenty six g of representative well-mixed sample of dried whole milk were taken in a sterile beaker having a capacity of 250 ml. An amount of 200 ml of distilled water having a temperature of 75⁰ C and pH 7±0.02 was added and agitated for 90 seconds with a stirrer (according to laboratory, manual, methods of analysis of milk and milk products 1964b and American Dry Milk Institute, 1942). Then the sample was subjected to analysis for solids-non-fat, total solids, fat %, specific gravity, and acidity assessment.

3.2.2 Preparation of dilution

A quantity of 11 g of powder milk was weight out in a sterile stopper bottle having 99 ml of distilled water to get 1:10 dilution according to the laboratory manual, methods of analysis of milk and milk products. The bottle was shaken vigorously 25 times up and down in a period of 7 seconds over a distance of about 30 centimeter. Then the samples were subjected to microbial assessment and analysis.

3.3 Parameters studied

The following physical, chemical and microbiological tests were carried from each powder milk samples collected from the market.

3.3.1 Physical tests

- a) Organoleptic
 - i) Flavour
 - ii) Taste
 - iii) Colour
 - iv) Odour
 - v) Appearance
- b) Specific gravity

3.3.2 Chemical tests

- a) Acidity
- b) Fat
- c) Protein
- d) Lactose
- e) Ash
- f) Moisture
- g) Solids-non-fat (SNF)
- h) Total solids (TS)

3.3.3 Microbiological tests

- a) Total viable bacteria count
- b) Coliform bacteria count

3.4 Procedure

Organoleptic test was done visually, nasally, linguallly by a panel of experts. The judging was carried out according to the standard dry milk scorecard as shown in the appendix section

recommended by “Judging of Dairy products” (Nelson and Trout, 1955a). Specific gravity test was performed by using Quenvne lactometer floating dairy thermometer according to the method described by Aggarwala and Sharma (1961). Fat test was performed by Gerber method. Acidity test was done by titrating milk with N/10 NaOH solution as per method described as AOAC (1971), protein was estimated by Kjeldhal method (total nitrogen estimation). The solids non fat (SNF) and total solids (TS) of reconstitute milk was determined according to Eckles *et al.* (1951c). Total solids, moisture and ash of the experimental powder milk were determined according to the method described by AOAC (1980). Lactose and solids-non-fat of powder were determined by following calculation:

Lactose = total solids – (fat + protein + ash)

Solids-non-fat = total solids – fat

The experimental procedure followed for the determination of the number of total viable bacteria in a sample. The detection and enumeration of Coliform bacteria were as per recommendation of “Standard methods for the examination of dairy products” (1967).

3.4.1 Determination of Specific gravity

The temperature of reconstitute milk was adjusted to near about 60°C. The milk was mixed thoroughly by avoiding incorporation of air and was poured gently from one container to another. Enough milk was placed in a cylinder so that the lactometer was placed in the centre of the cylinder and reading was done within 30 seconds after mixing. Again the temperature of milk was taken. The lactometer reading was taken from the lactometer scale at the top of the milk meniscus. If the milk temperature was not exactly 60°F, the lactometer reading was corrected by adding 0.1 degree for each of Farhenheit temperature above 60°F or by subtracting 0.1 degree for each of Farhenheit temperature below 60°F. Specific gravity of milk sample was calculated by the following formula:

$$\text{Specific gravity} = \frac{\text{CLR}}{1000} + 1$$

Where, CLR = Corrected Lactometer reading.

3.4.2 Determination of acidity

Reconstitute milk (17.6ml) was taken into a beaker by a milk pipette. Five (5) drops of phenolphthalein was added into the milk and shaken well to mix properly. 0.1 NaOH solution was taken in a burette and the solution was poured in milk sample drop by drop and the content of beaker was stirred during time. Appearance of visible pink color during titration indicated the end point of reaction. The volume of 0.1 N NaOH used from burette was noted and the acidity was calculated by using the following formula-

$$\text{Percentage of acidity} = \frac{\text{ml of NaOH used} \times \text{Strength of NaOH}}{\text{ml eq. wt. lactic acid}} \times 100$$

$$\text{Percentage of acidity} = \frac{\text{ml of 0.1 NaOH} \times 0.1 \times 0.09}{\text{Weight of sample}} \times 100$$

Where 0.009 is the grams of lactic acid equivalent to each ml of normal strength of NaOH. 17.6 ml milk is equivalent to 18gms of milk and 0.1 N was the normality of NaOH used.

3.4.3 Determination of fat percentage of milk (Gerber Method)

Gerber Method determines the percentage of fat. Ten milliliter of sulfuric acid was taken into a Gerber butyrometer and 10.94 ml of mixed reconstitute milk sample was taken into milk pipette and was poured slowly on the top of the sulfuric acid avoiding wetting the neck of the butyrometer. One ml of amyl alcohol was added to sample by automatic filter. The neck of the butyrometer was closed with a stopper and was shaken well until dark red colour appeared and white particles disappeared. The butyrometer was centrifuged at 1100 rpm for 5 minutes and later was placed in water bath at 65°C for 3 minutes. The fat percent was estimated by the lower meniscus to the upper meniscus of the fat column from the graduated marks of the butyrometer. Fat % of reconstituted milk converted into the fat % of milk powder.

$$\text{Percentage of fat} = \frac{\text{Reconstitute fat \%} \times \text{powder total solids}}{\text{Weight of sample}} \times 100$$

3.4.4 Determination of protein

Two gm of each sample, whose dry matter percentage was known, transferred in Kjeidhal flask. One gm of mixed catalyzer was added to each flask. Then 20 ml of commercial concentrated sulfuric acid was poured gradually into each Kjeidhal flask containing the sample. The flask was kept in digestion chamber in inclined position and was heated gently until the solution become frothing ceases. Boiling was continued for 30 min until the solution become clear. After digestion, the digested solution was cooled and 100 ml of distilled water was added to the digested sample. Some zinc granules were added to prevent bumping. The digested solution was then neutralized by adding 80 ml of 40% NaOH solution without agitation. The flask was immediately connected to digest bulb on condenser and then tip of condenser was immersed in a Erlenmeyer flask containing 20 ml of 2% boric acid solution. The flask was rotated to mix the content thoroughly and was heated until all ammonia was distilled. The distillate was titrated with standard hydrochloric acid solution (0.1N) using mixed indicator (methyl blue + methyl red) and the percent of nitrogen was calculated as follows:

$$\text{Percentage of N}_2 = \frac{\text{Normally of acid x ml eq. wt. of N}_2 \times \text{ml of acid required}}{\text{Weight of sample}} \times 100$$

Thus, nitrogen percent obtained was multiplied by 6.38 in order to obtain protein percent. Following the above procedure the protein percentage of each sample was determined.

3.4.5 Determination of lactose of dried milk

$$\text{Lactose} = \text{Total solids} - (\text{Fat} + \text{Protein} + \text{Ash})$$

3.4.6 Determination of ash

The crucibles were placed in a muffle-furnace at 550°C for drying. After one-hour crucible were transferred from muffle-furnace, cooled and weight out. The supplied sample was taken inside the previously weighed crucible and weighed out and marked it properly and the sample was burned on an electric heater till the smoke removed. The crucible with its content was transferred inside the muffle-furnace and was ignited at 600°C temperature for five

hours. After ignition the crucible was removed and cooled in a desiccator and then it was weight out. Ash content of the sample was calculated as follows:

$$\text{Percentage of ash} = \frac{\text{Wt. of the after ignition}}{\text{Weight of sample}} \times 100$$

3.4.7 Determination of moisture of milk powder

Moisture was determined by moisture determination balance (bFD – 600) of Quality Control Laboratory of Bangladesh Milk Producers' Co-operative Union Limited (Milk Vita) at Mirpur of Dhaka.

3.4.8 Determination of solids non fat (S.N.F) of dried milk

SNF = Total solids – fat

3.4.9 Determination of solids non fat (S.N.F) and total solid (TS) of reconstitute dried milk

S.N.F of milk samples were determined by calculation after present and correct lactometer regarding of milk samples obtained.

$$\text{S.N.F} = \frac{\text{CLR}}{4} + 0.2 \times \text{fat \%} + 0.14$$

$$\text{T.S} = \text{SNF} + \text{fat \%}$$

Here, CLR = Corrected lactometer reading.

3.4.10 Determination of total viable count of bacteria by pour plate Technique

The pour plate technique was followed in determining the general viable count. Standard procedures as described in “Standard methods for the examination of Dairy products” were adopted. In this study SPC standard plate count agar was used (Himedia laboratories, Ltd. Bombay, India). The composition and the preparation of SPC agar is given below.

3.4.10.1 Standard plate count (SPC) agar

Composition:

Casein enzymic hydroly-sate	5.0g
Yeast extracts	2.5g
Dextrose	1.0g
Agar	15.0g
Total	23.5g
Distilled water	1000.00ml

3.4.10.2 Preparation

To rehydrate the medium, 23.5g of SPC agar was suspended in 1000 ml of cold distilled water ($\text{pH} = 7 \pm 0.01$) and heated to boiling to dissolve the medium completely, dispersed in measured 100 ml bottles and sterilized in an autoclave at 121°C (6.795kg pressure/sq. inch) for 20 minutes. The final reaction was adjusted to $\text{pH} 7 \pm 0.01$. Pouring of plate was done according to "Standard methods for the examination of dairy products".

3.4.10.3 Preparation of dilution blanks

One thousand ml of distilled water was taken in flask. The phosphate buffer solution prepared as per recommendation of the "Standard methods for the examination of dairy products" was added to the distilled water at the rate of 1.25-ml/1000 ml and the pH was adjusted to 7 ± 0.02 . The dilution blanks dispersed into general dilution bottles at the rate of 100 ml per bottle. Later the dilution blanks were sterilized in an autoclave at 121°C (6.795kg pressure/sq. inch) for 20 minutes. The sterilized dilution blanks were kept in a refrigerator until use.

3.4.10.4 Procedure of plating SPC agar

The procedure of plating the sample on the medium was performed according to the the "Standard methods for the examination of dairy products". 1.1 ml of reconstituted dried milk from each sample was taken by using 1.1 pipette. 0.1 ml was transferred into a Petri dish and 1 ml was transferred into 99 ml portion of sterile phosphate buffer distilled water dilution blank and the sample was shaken vigorously 25 times up and down in a period of 7

seconds over a distance of about 30 cm. Then, using a sterile pipette, 1.1 ml portion of sample was taken from diluted sample. One ml was taken into 2nd Petri dish and 0.1 ml into the 3rd Petri dish to get the dilution of 1:10, 1:100. Fifteen (15) ml of sterilized melted agar, cooled to 45°C, was then added to each plate by slightly raising the lid of the Petri dish and was mixed thoroughly with a gentle rotary motion. The agar was allowed to solidify and then the plates were inverted and placed in an incubator at 32°C for 48 hours. After the prescribed incubation period the inoculated medium was taken out from the incubators and the colonies were counted with the help of Quebec colony counter from the suitable Petri dish. The colony numbers were multiplied by the dilution and final count per gram of sample was recorded.

3.4.11 Determination of Coliform count

Violet red bile (VRB) agar was used to enumerate the Coliform in the experiment as described in the “Standard methods for the examination of dairy products”. The composition and preparation of VRB agar medium is given below (Himedia laboratories, Ltd. Bombay, India).

3.4.11.1 Violet red bile (VRB) agar

Composition:

Yeast	3.0g
Peptone	7.0g
Bile salt	1.5g
Lactose	10.0g
Sodium chloride	5.0g
Neutral red	0.03g
Crystal violet	0.002g
Agar (Bacto agar)	15.0g
Total	41.5g
Distilled water	1000.00ml.

3.4.11.2 Preparation

To rehydrate the medium, 41.5g Of VRB agar was suspended in 1000 ml of cold distilled water ($\text{pH} = 7 \pm 0.02$) mixed thoroughly and heated to boiling to dissolve the medium completely. Later, the medium was transferred into several sterilized sample bottles. The final reaction was adjusted to $\text{pH} 7 \pm 0.01$. The medium was then ready for planting or storing. Before planting, the stored medium was melted and cooled at 45°C . Pouring of plate was done according to “Standard methods for the examination of dairy products”.

3.4.11.3 Procedure of plating VRB agar

The procedure of plating the sample on the medium was performed according to the the “Standard methods for the examination of dairy products”. One ml portion of reconstituted dried milk was placed into a sterilized Petri dish aseptically in order to get the dilution 1:10 from each sample.

Fifteen ml of sterilized and melted VRB agar, cooled to 45°C , was then added to each plate by slightly raising the lid of the Petri dish and was mixed thoroughly with a gentle rotary motion. The agar was allowed to solidify and a few ml (5 ml) of medium was added to give a surface layer. Then the plates were inverted and placed in an incubator at 32°C for 48 hours. After the prescribed incubation period, the inoculated medium was taken out from the incubators and the colonies (normally at least 0.5 mm in diameter) were counted. The colony numbers were multiplied by the dilution and final count per gram of sample was recorded.

3.5 Statistical Analysis

There were six types of packaged powder milk samples in this experiment and experimental material was completely homogenous. Hence, the statistical analysis was done as per Steel Torrie (1980), using Completely Randomized Design (CRD). Analysis of variance test was done to find out the statistical difference within the quality of the six types of packaged powder milk.

CHAPTER 4

RESULTS, DISCUSSION AND CONCLUSION

RESULTS AND DISCUSSION

4.1 Physical parameters

The physical parameters studied on selected full cream powder milk available in the market of Bangladesh, were mainly organoleptic tests (flavour, taste, colour, odour, appearance) and specific gravity.

4.1.1 Organoleptic tests

4.1.1.1 Flavour

Flavour score of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 37.1 ± 3.26 , 36 ± 3.16 , 37.8 ± 1.86 , 36.8 ± 5.75 and 36.1 ± 3.61 respectively (Table-1). Statistically there were no significant differences within the flavour of different types of powder milk samples collected from market (Appendix Table-1). It was found that average score of flavour obtained from Anchor was comparatively higher (37.8 ± 1.86) and Starship was comparatively lower (36.1 ± 3.61) than that of flavour score of powder milk of other four samples. Rahman (1987) found that the average flavour of dried powder milk was fair quality. The principal defect in flavour is caused by rancidity. Any considerable amount of rancidity renders powder unit of human food (Mojonnier and Tory, 1925). The flavour of full cream powder milk should be clean rich, sweet and very pleasant not unlike that of fone pastry (Porcher, 1929). Oxidized totally flavour is the most troublesome flavour defect of dry whole milk (Nelson and Trout, 1955a). The experimental results show that the samples were free from any off or rancid flavour and were within acceptable range.

4.1.1.2 Taste

Average score of taste of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 28.1 ± 1.86 , 27.3 ± 1.67 , 27.9 ± 2.08 , 27.4 ± 1.80 and 27.7 ± 1.47 respectively (Table-1). Statistically there were no significant differences within the taste of different types of powder milk collected from market (Appendix Table-2). It was found that average score of taste obtained from Milk Vita was comparatively higher (28.1 ± 1.86) and Dano was comparatively lower (27.3 ± 1.67) than that of taste score of powder milk of other four samples. Dry milk solids may be unduly criticized as having a heated or cooked taste

(Porcher, 1929). Dry full cream milk has a pleasant taste, somewhat sweetish and slight suggestion heated milk (Eckless *et al.*, 1951b). The taste of the experimental samples was appropriate in high degree.

4.1.1.3 Colour

Score of colour of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 7.5 ± 1.85 , 7.5 ± 1.43 , 8.0 ± 1.43 , 8.1 ± 1.29 and 8.9 ± 1.45 respectively (Table-1). Statistically there were significant differences within the colour of different types of powder milk collected from market (Appendix Table -3). It was found that average score of colour obtained from Starship was comparatively higher (8.9 ± 1.45) and Dano was comparatively lower (7.5 ± 1.43) than that of colour score of powder milk of other four samples. The colour of Starship was golden yellow and other samples were light yellow colour. However, there were no criticisms of any samples. Colour of dry milk is influenced by the carotene content of the milk, if the milk from which the dry milk is made is rich in carotene, the resulting product will possess a darker yellow than that made from lacking carotene. When milk of a relatively high acidity is dried, the resulting material appears dark in colour (Eckless *et al.*, 1951b). There were significant differences between Starship and other samples; this is due to presence of carotene and acidity content in high degree in raw milk from which Starship powder milk was prepared.

4.1.1.4 Odour

Average score of odour of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 9.1 ± 1.20 , 8.6 ± 1.85 , 8.5 ± 1.56 , 8.7 ± 1.65 and 8.3 ± 1.70 respectively (Table-1). Statistically there were significant differences within the odour of different types of powder milk collected from market (Appendix Table-4). It was found that average score of odour obtained from Milk Vita was comparatively higher (9.1 ± 1.20) and Starship was comparatively lower (8.3 ± 1.70) than that of odour score of powder milk of other four samples. Bad odours usually indicate either improper manufacturing process or decomposition of the product (Mojonnier and Tory, 1925). The freshly prepared powders have an agreeable and appetizing odour like that of fine pastry (Porcher, 1929).

4.1.1.5 Appearance

Appearance score of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 8.4 ± 0.97 , 8.6 ± 1.14 , 8.7 ± 1.20 , 8.5 ± 1.65 and 8.0 ± 1.41 respectively (Table-1). Statistically there were non-significant differences within the appearance of different types of powder milk collected from market (Appendix Table-5). It was found that average value of appearance score obtained from Anchor was comparatively higher (8.7 ± 1.20) and Starship was comparatively lower (8.0 ± 1.41) than that of appearance score of powder milk of other four samples. However, there were no criticisms of all samples. "Appearance white to slightly yellowish cast, no dark lumps or specks powder is to be homogeneous throughout" (Mojonnier and Tory, 1925). The powders prepared by spray process are extremely fine and very homogeneous (Porcher, 1929). Certain physical changes take place, which cause the dry milk to form very hard lumps if it is permitted to take up moisture from the air (Eckless *et al.*, 1951b). "A lump powder definitely lacks homogeneity. Hard lumps ranging in size from a grain of wheat upwards may be interspersed throughout the solids and caked dry whole milk has lost its powdery consistency and has become a rock like solid" (Nelson and Trout, 1955a). The experimental results show that the samples were free from any unpleasant appearance and were within acceptable range.

Table 1: Organoleptic test score (Mean $\pm$ SD) of different brands of full cream powder milk

Sample sources	Obtained score of different parameters					Total score (%)
	Flavour	Taste	Colour	Odour	Appearance	
Milk Vita	37.1 ± 3.26	28.1 ± 1.86	7.5 ± 1.85	9.1 ± 1.20	8.4 ± 0.97	90.1
Dano	36 ± 3.16	27.3 ± 1.67	7.5 ± 1.43	8.6 ± 1.85	8.6 ± 1.14	88.8
Anchor	37.8 ± 1.86	27.9 ± 2.08	8.0 ± 1.43	8.5 ± 1.56	8.7 ± 1.20	90.9
Diploma	36.8 ± 5.75	27.4 ± 1.80	8.1 ± 1.29	8.7 ± 1.65	8.5 ± 1.65	89.1
Starship	36.1 ± 3.61	27.7 ± 1.47	8.9 ± 1.45	8.3 ± 1.70	8.0 ± 1.41	89.0
Level of significance	NS	NS	S	S	NS	S

NS = Non significant

S = Significant

4.1.1.6 Total score

The total organoleptic score of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 90.1, 88.8, 90.9, 89.1 and 89.0 %, respectively (Table 1). Statistically there were significant differences within the total score of different types of powder milk collected from market (Appendix Table-6). It was found that average total score obtained from Anchor and Milk Vita were comparatively higher (90.9 and 90.1% respectively) and Dano was comparatively lower (88.8 %). From the present study it was found that Dano, Starship and Diploma were comparatively better than the other brands. Amrita-Kadian *et al.* (1988) found that the Organoleptic quality of majority samples of powder milk was graded good (80-89%), while three brands of powder milk were graded fair (60-79%) as per Bureau of Indian Standard. There were significant differences between Dano and Milk Vita and Anchor. This difference is due to the significant differences between colour and odour.

4.1.1.7 Specific gravity

Specific gravity of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 1.0270 ± 0.00 , 1.0265 ± 0.00 , 1.0274 ± 0.00 , 1.0268 ± 0.00 and 1.0269 ± 0.00 respectively (Figure-1). Statistically there were no significant differences within the specific gravity of different types of powder milk samples collected from market (Appendix Table-7). It was known that the normal range of specific gravity of whole milk is 1.027 to 1.035 within an average of 1.032 (Eckles *et al.* 1951a). Ali (1999) found that the average specific gravity of milk samples of BAU Dairy Farm, different whole milk supplies and Vender's were 1.030 ± 0.00 , 1.030 ± 0.00 and 1.026 ± 0.00 respectively, which were within the range of present experimental results. From the present study it was found that the specific gravity of the experimental samples were within the normal range.

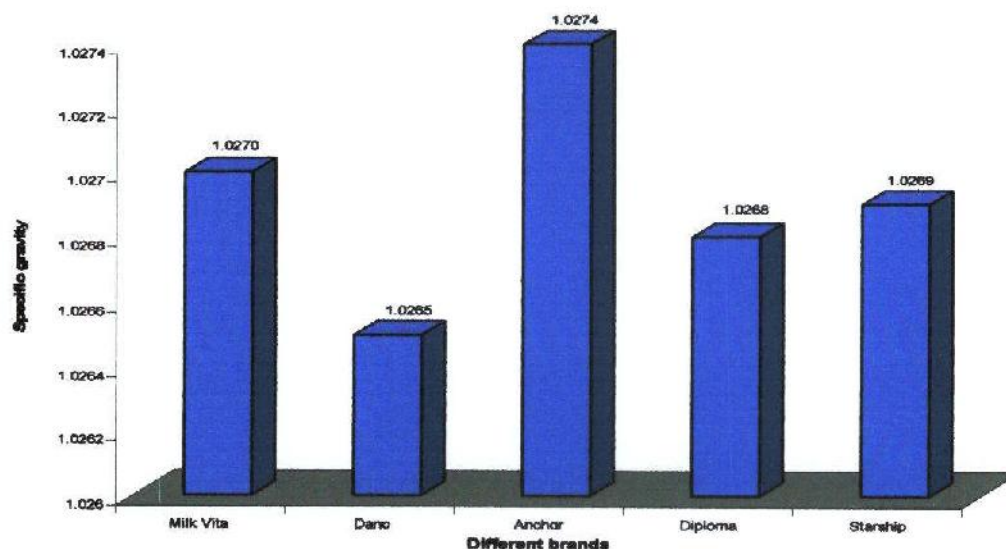


Fig-1. Specific gravity (g/100g) of different full cream powder milk samples

4.2 Chemical Parameters

4.2.1 Acidity

Acidity percentage of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 1.04 ± 0.008 , 1.07 ± 0.010 , 1.00 ± 0.007 , 1.09 ± 0.005 and 1.10 ± 0.004 respectively (Figure-2). Statistically there were no significant differences within the acidity content of different types of powder milk collected from market (Appendix Table-8). It was found that the average value of acidity obtained from Diploma and Starship were comparatively higher (1.09 ± 0.005 and 1.10 ± 0.004 respectively) and Anchor was lower (1.00 ± 0.007) than the acidity of whole milk of other samples. According to BSTI and ADMI (1971), maximum acidity % of dry whole powder milk is 1.6. The present study was below according to the BSTI and ADMI standard). The present experimental results show that the samples were free from any undesired acidity and were within acceptable range.

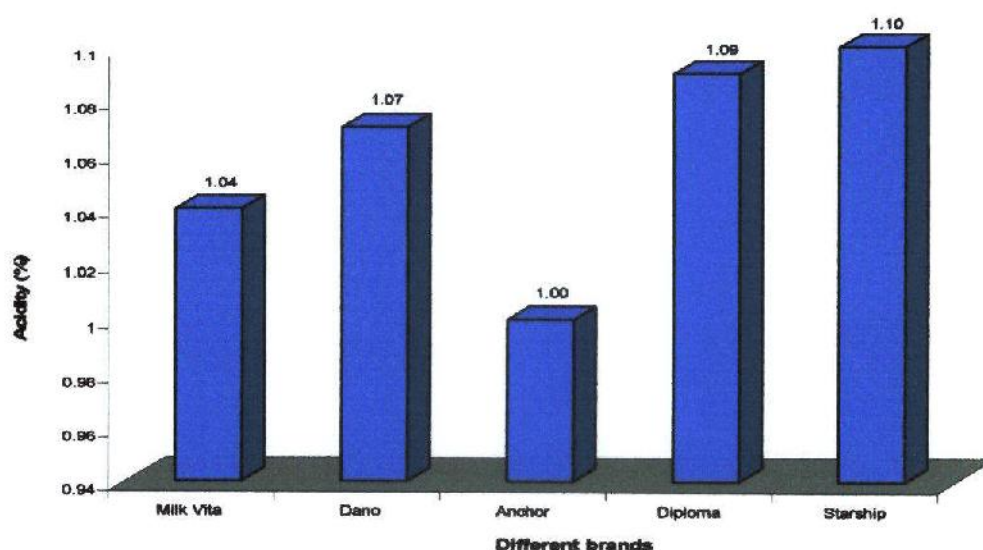


Fig-2. Average acidity (%) of different full cream powder milk samples

4.2.2 Fat

Fat percentage of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 26.36 ± 0.125 , 25.56 ± 0.375 , 26.125 ± 0.250 , 26.125 ± 0.250 and 26.00 ± 0.0479 respectively (Figure-3). Statistically there were no significant differences within the fat content of different types of powder milk collected from market (Appendix Table-9). It was found that the average value of fat obtained from Milk Vita, Anchor and Diploma were comparatively higher (26.36 ± 0.125 and 26.125 ± 0.250 respectively) and Dano was lower (25.56 ± 0.375) than the fat content of whole milk of other samples. The result agree with the work of Buma (1968) reported that the average value of fat of spray dried whole powder milk was 28%. In another experiment, Pijanowski (1975) found that the average fat % of whole milk was 25.4%. According to the BSTI and ADMI (1971) average fat content of dried whole powder milk are minimum 26% and 26% respectively. The present study was agreed with the BSTI and ADMI standards. Dry whole milk contains minimum 26% fat (Eckles *et al.* 1951b). Therefore, the experimental results indicate that the fat percentage of the samples were within the normal range.

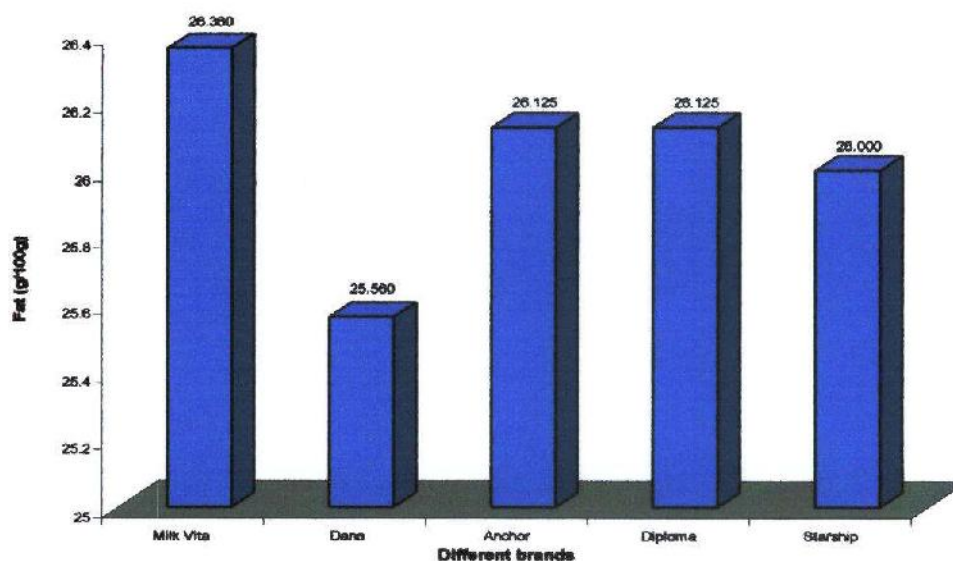


Fig-3. Average value of fat (g/100g) content of different full cream powder milk samples

Table 2. Physical, chemical and microbial quality of different full cream powder milk samples

Parameters	Milk Vita	Dano	Anchor	Diploma	Starship	BSTI standard	Level of significance
Specific gravity	1.0270 ± 0.00	1.0265 ± 0.00	1.0274 ± 0.00	1.0268 ± 0.00	1.0269 ± 0.00	1.028	NS
Acidity (%)	1.04 ± 0.008	1.07 ± 0.010	1.00 ± 0.007	1.09 ± 0.005	1.10 ± 0.004	1.6(m _x)	NS
Fat (g/100g)	26.36 ± 0.125	25.56 ± 0.375	26.125 ± 0.250	26.125 ± 0.250	26.00 ± 0.0479	26	NS
Protein (g/100g)	26.87 ± 0.050	26.65 ± 0.289	26.25 ± 0.096	26.41 ± 0.250	26.93 ± 0.289	26	NS
Ash (g/100g)	5.90 ± 0.285	6.15 ± 0.058	5.95 ± 0.850	6.00 ± 0.69	6.13 ± 0.082	8.8(m _x)	NS
Moisture (g/100g)	2.76 ± 0.096	3.69 ± 0.263	2.97 ± 0.096	3.88 ± 0.096	3.93 ± 0.096	5(m _x)	NS
Lactose (g/100g)	38.00 ± 0.521	38.50 ± 0.310	38.18 ± 0.208	38.23 ± 0.316	37.03 ± 0.035	38	NS
SNF (g/100g)	71.00 ± 0.252	71.30 ± 0.137	70.38 ± 0.452	69.64 ± 0.330	71.09 ± 0.283		NS
TS (g/100g)	97.36 ± 0.36	96.86 ± 0.536	96.51 ± 0.287	95.77 ± 0.096	97.09 ± 0.085	97	NS
Total Viable Bacteria	400 ± 75.65	500 ± 58.75	500 ± 57.79	300 ± 81.65	500 ± 50.00	1000	NS
Coliform bacteria	Nill	Nill	Nill	Nill	Nill		NS

NS = Non significant

4.2.3 Protein

Protein (g/100g) of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 26.87 ± 0.050 , 26.65 ± 0.289 , 26.25 ± 0.096 , 26.41 ± 0.250 and 26.93 ± 0.289 respectively (Figure-4). Statistically there were no significant differences within the protein content of different types of powder milk collected from market (Appendix Table-10). It was found that the average value of protein obtained from Starship and Milk Vita were comparatively higher (26.93 ± 0.289 and 26.87 ± 0.050 respectively) and Anchor was lower (26.25 ± 0.096) than the protein content of whole milk of other samples. Simiva and Ruzickova (1979) found that the average protein content of dried whole milk was 25.0-25.4%. Radaeva *et al.* (1995) found that the average protein content of dried whole milk was 25g/100g. This study was almost similar to that of ADML. Standard Dry whole milk contains 27.20% protein (Eckles *et al.*). Therefore, the experimental results indicate that the protein content of the samples were within the acceptable range.

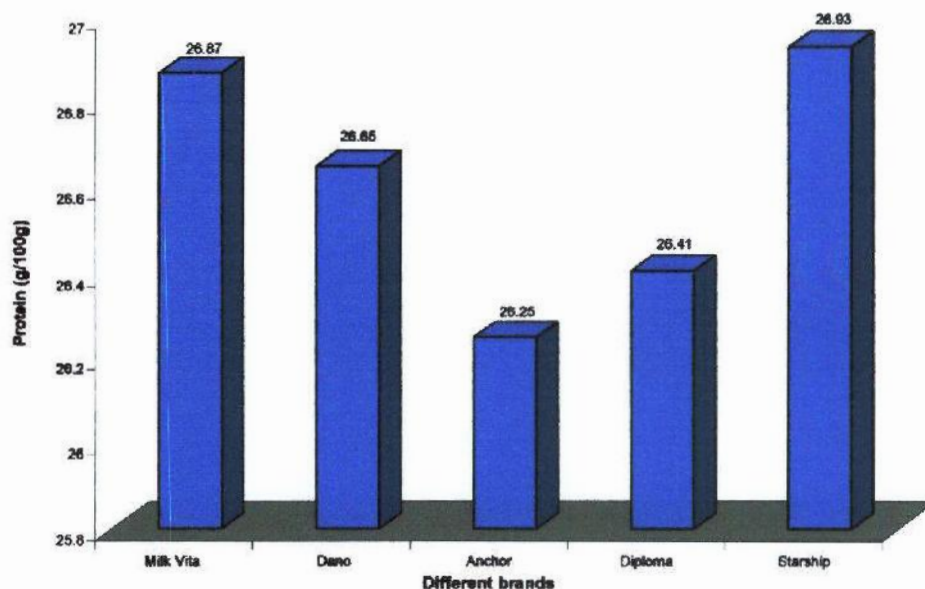


Fig-4. Average protein (g/100g) content of different full cream powder milk samples

4.2.4 Ash

Ash (g/100g) of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 5.90 ± 0.285 , 6.15 ± 0.058 , 5.95 ± 0.850 , 6.00 ± 0.69 and 6.13 ± 0.082 respectively (Figure-5). Statistically there were no significant differences within the ash content of different types of powder milk collected from market (Appendix Table-11). It was found that the average value of ash obtained from Starship was comparatively higher (6.13 ± 0.082) and Milk Vita was lower (5.90 ± 0.285) than the ash content of whole milk of other samples. Kumar and Murthy (1992) reported that the ash content of buffalo whole milk from three batches were 5.62, 5.41 and 5.69 g/100g. Amrita Kadin *et al* (1998) found that the ash content of partly skimmed powder milk was 5.59%. In another experiment Watt and Merrill (1963) found that the average ash of dry whole milk was 5.9 g/100g that is almost similar with the ash percentage of powder milk samples of present study. According to the BSTI, average ash content of whole powder milk is 7.3%. Dry whole milk contains 6% ash (Eckelese *et al.*, 1951b). The present experimental results show that the ash content of the samples were within acceptable range.

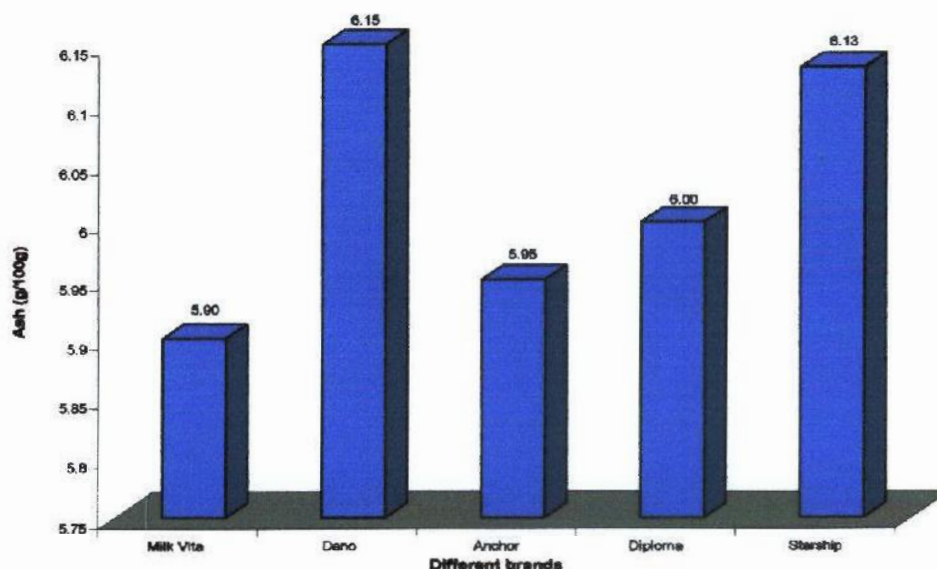


Fig-5. Average ash (g/100g) content of different full cream powder milk samples

4.2.5 Moisture

Moisture content of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 2.76 ± 0.096 , 3.69 ± 0.263 , 2.97 ± 0.096 , 3.88 ± 0.096 and 3.93 ± 0.096 respectively (Figure-6). Statistically there were no significant differences within the moisture content of different types of powder milk collected from market (Appendix Table-12). It was found that the average value of moisture from Starship was comparatively higher (3.93 ± 0.096) and Milk Vita was lower (2.76 ± 0.096) than the moisture content of whole milk of other samples. Kumar and Murthy (1992) reported that the moisture content of buffalo whole milk from three batches were 3.73, 2.62, 3.33 g/100g. In another experiment, Pijanowski (1975) found that the average moisture of whole powder milk was 2.74%. According to the BSTI the moisture content of whole powder milk is 4%. According to the ADMI (1971) the moisture of whole powder milk is within the range of 2-5%. Moisture content of above 4% is not acceptable in whole powder milk as the moisture of above this level has been found to accelerate several chemical changes leading to development of off-flavours (Tarassuk and Jack, 1948). Results of present study agreed with the above experimental results.

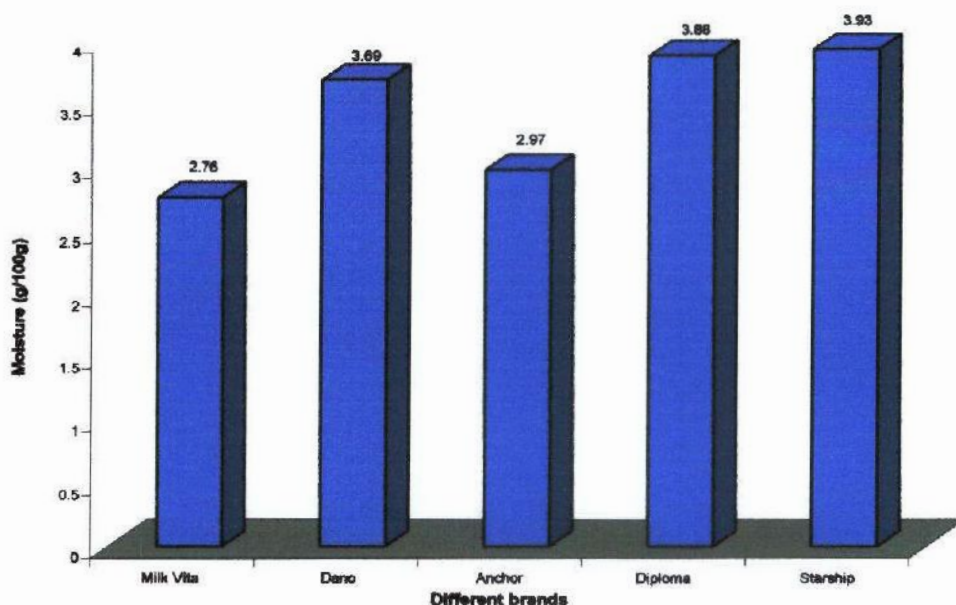


Fig-6. Average moisture (g/100g) content of different full cream powder milk samples

4.2.6 Lactose

Lactose (g/100g) of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 38.00 ± 0.521 , 38.50 ± 0.310 , 38.18 ± 0.208 , 38.23 ± 0.316 and 37.03 ± 0.035 respectively (Figure-7). Statistically there were no significant differences within the lactose content of different types of powder milk collected from market (Appendix Table-13). It was found that the average value of lactose obtained from Dano was comparatively higher (38.50 ± 0.310) and Starship was lower (37.00 ± 0.521) than the lactose content of whole milk of other samples. According to the ADMI (1962), lactose content of dry whole milk is 38.2 g/100g. From the present study it was found that the lactose content of Milk Vita, Dano, Anchor, Diploma and Starship were similar with the ADMI standard. Lactose content of Starship was below the standard of ADMI. Dry whole milk contains 36.80% lactose (Eckelese *et al.*, 1951b). Therefore, the experimental results indicate that the lactose content of the samples were within the normal range.

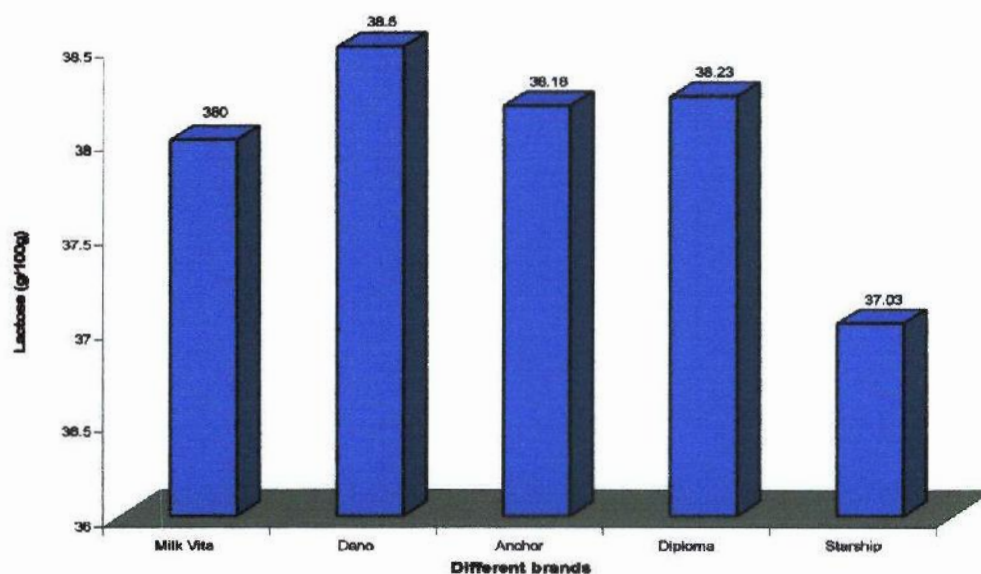


Fig-7. Average lactose (g/100g) content of different full cream powder milk samples

4.2.7 Solid-non Fat (SNF)

Solid-non Fat (SNF) content of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 71.00 ± 0.252 , 71.30 ± 0.137 , 70.38 ± 0.452 , 69.64 ± 0.330 and $71.09 \pm 0.0.283$ respectively (Figure-8). Statistically there were no significant differences within the Solid-non Fat (SNF) content of different types of powder milk collected from market (Appendix Table-14). It was found that the average value of solid-non Fat (SNF) obtained from Dano and Starship were comparatively higher (71.30 ± 0.137 and $71.09 \pm 0.0.283$ respectively) and Diploma was lower (69.64 ± 0.330) than the solid-non Fat (SNF) content of full cream powder milk of other samples. According to the FAO/WHO (1973), the average SNF content of whole powder milk is 69%. Pijanowski (1975) found that the average SNF of whole fresh powder milk was 72.86%. In another experiment Burma (1968) reported that the average percentage of SNF of spray dried whole milk was 70%. From an experiment Kumar and Murthy (1992) found that the average SNF of buffalo whole milk from three batches were 70.47, 71.38 and 70.67 g/100g. From the present study it was found that solid-non Fat (SNF) content of all milk samples were nearest to the normal value (70%) recommended by BSTI.

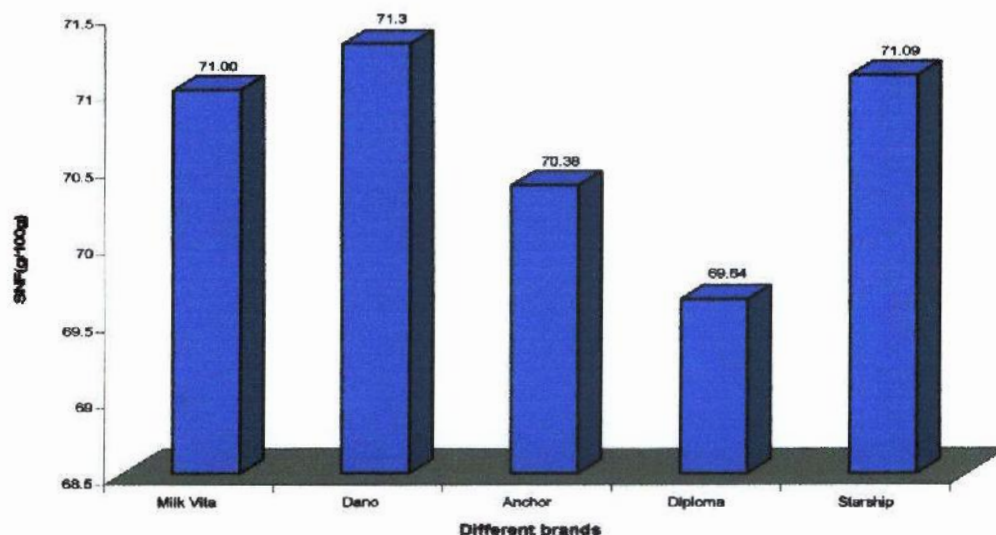


Fig-8. Average Solid-non Fat (g/100g) content of different full cream powder milk samples

4.2.8 Total Solids (TS)

Total Solids (TS) content of full cream powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 97.36 ± 0.36 , 96.86 ± 0.536 , 96.51 ± 0.287 , 95.77 ± 0.096 and 97.09 ± 0.085 respectively (Figure-9). Statistically there were no significant differences within the total solids (TS) content of different types of powder milk collected from market (Appendix Table-15). It was found that the average value of total solids (TS) obtained from Milk Vita and Starship were comparatively higher (97.36 ± 0.367 and 97.09 ± 0.085 respectively) and Diploma was lower (95.77 ± 0.096) than the total solids (TS) content of whole milk of other samples. Pijanowski *et al.* (1975) found that the average TS of whole powder milk were $97.26\text{g}/100\text{g}$. Korolezuk *et al.* (1968) reported that the total solids of spray-dried whole milk from three experiments were 98.22, 97.00 and 97.59%. Kumar and Murthy (1992) found that the average total solids (TS) of buffalo whole powder milk from three batches were 96.27, 97.38 and $96.67\text{ g}/100\text{g}$. According to the BSTI, average total solids content of powder milk is 96%. According to the ADMI (1971), the total solids of whole powder milk is within the range of 98-95%. Total solids of powder milk are 96% (Eckelese *et al.*, 1951b). The present study indicates that the TS content of the collected samples were within the normal range (95 to 98%). The present study agreed with the above results of different experiments.

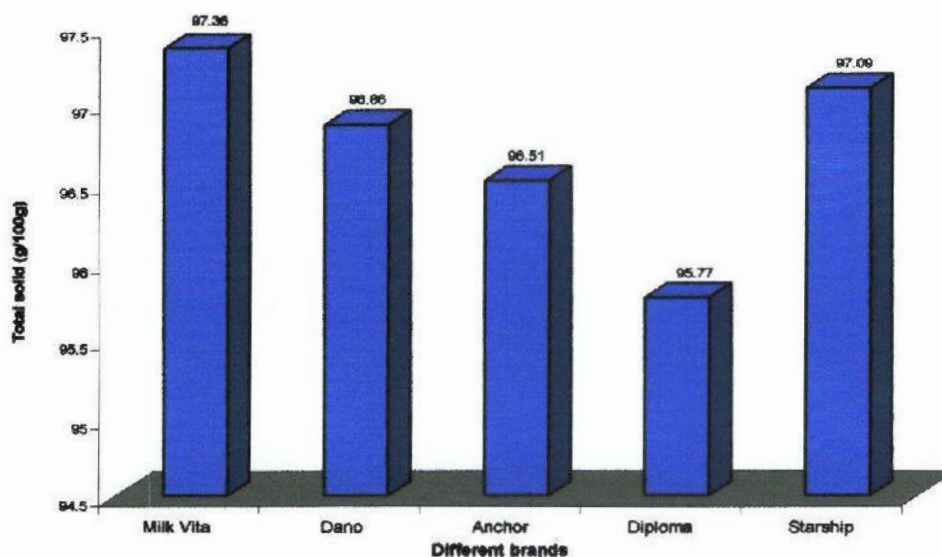


Fig-9. Average total solids (g/100g) content of different full cream powder milk samples

4.3 Microbiological Study

4.3.1 Total Viable Bacteria count

Total viable bacteria of powder milk from Milk Vita, Dano, Anchor, Diploma and Starship were 400 ± 75.65 , 500 ± 58.75 , 500 ± 57.79 , 300 ± 81.65 and 500 ± 50.00 respectively (Figure-10 and 11). Statistically there were no significant differences within the total viable bacteria content of different types of powder milk samples collected from market (Appendix Table-16). It was found that the average value of total viable bacteria obtained from Dano, Anchor and Starship were comparatively higher (500 ± 58.75 , 500 ± 57.79 and 500 ± 50.00 respectively) and Diploma was lower (300 ± 81.65) than the total viable bacteria content of whole powder milk of other samples. Maximum bacterial count of dried whole milk is 31,00/g (American Dry Milk Institute, 1971). The present experimental results show that bacterial population of all samples was within the normal range of ADMI standard. Arora (1989) found that in the spray dried skim milk sample bacterial count was 2000 to 160,000/g. Total viable count of powder milk ranged from 200,000 to 4,30,000/g (Rahman *et al.*, 1988). Mean bacterial count is 28000/g of dry milk (Hall *et al.*, 1968). The present experimental results show that the bacterial population was within satisfactory range.

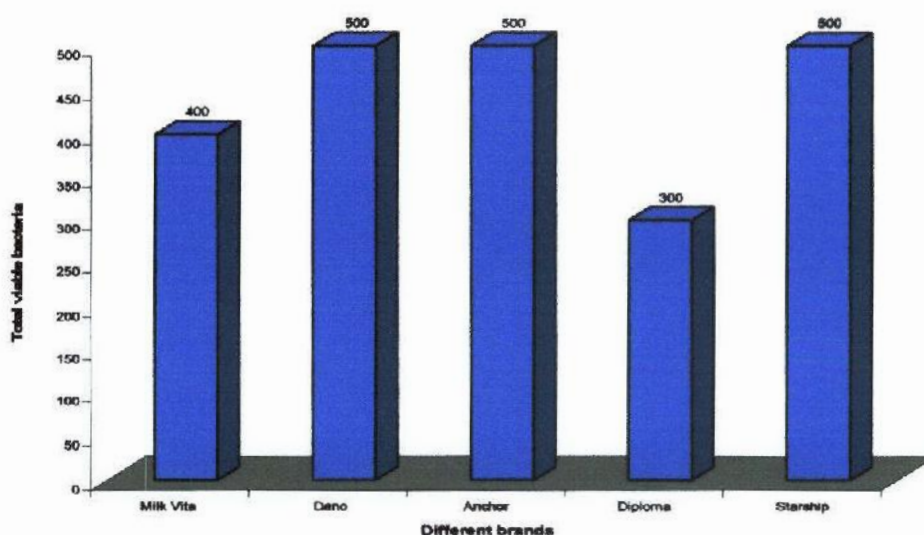


Fig-10. Total viable bacteria (g/100g) of different full cream powder milk samples



Plate -1 Diploma



Plate -2 Dano



Plate-3 Starship



Plate-4 Milk Vita



Plate-5 Anchor

Fig-11. Presence of total viable bacteria in different full cream powder milk samples

4.3.2 Coliform count

In the present study, there was no evidence of coliform bacteria in any of the samples (Figure- 12). Kumar and Murthy (1992) reported that total coliform count of buffalo whole powder milk was nil. In another experiment Hall *et al.* (1968) found that Grade a dried milk contained Coliform 2/g. According to BSTI, Coliform count not more than 90/g (U.S Dept. Agr. 1954). “The incidence of coliforms in any processed food is related to the unhygienic manufacturing techniques including poor plant sanitation and post processing contamination” (Arun *et al.*, 1970). The experimental results indicate that good sanitary measures are adopted during manufacture of the powder milk of the present sources.



Plate-1 Milk Vita



Plate-2 Dano



Plate-3 Diploma

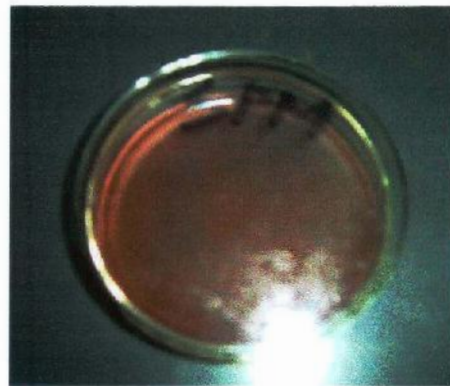


Plate-4 Starship



Plate-5 Anchor

Fig- 12. Indication of no coliform growth in different full cream powder milk samples

4.4 Conclusion

The experiment was conducted to evaluate the physical, chemical and microbiological qualities of different selected brands (Milk Vita, Dano, Anchor, Diploma and Starship) of full cream powder milk. According to the physical properties (flavour, taste, appearance and specific gravity) no significant differences were observed within the selected brands and the scores were within the acceptable range. However, significant differences were observed regarding colour and odour. According to chemical qualities (fat, solid-non-fat, total solids, protein, lactose, ash, acidity and moisture content), samples of Milk Vita and Starship were comparatively better than other brands. According to microbiological qualities, there were no coliform bacteria in the experimental samples. The total viable bacteria count of the experimental samples were within the acceptable range. However, the number of viable bacteria of Milk Vita and Diploma were less than that of others. From the experimental results it was observed that, powder milk of Milk Vita and Diploma were relatively better than the other selected brands, although no significant differences were observed regarding the quality. The present study reveals that the experimental full cream powder milk companies so far following the legal standard for manufacturing the full cream powder milk. However, there are other full cream powder milk brands available in our country rather than the present experimental five brands. Owing to lack of time and facilities, quality tests of all available full cream powder milk brands were not possible. To get the actual scenario of full cream powder milk quality of different brands it would be worthy to conduct further study considering all available full cream powder milk brands in the country.

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APPENDIX

APPENDIX TABLES

Appendix Table 1. Analysis of variance for flavor of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	4.115	4	1.029	5.274	0.150	5.99
Within Groups	1.951	10	0.195			
Total	6.066	14				

Appendix Table 2. Analysis of variance for taste of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	1.652	4	0.413	0.410	0.798	5.99
Within Groups	10.07	10	1.008			
Total	11.78	14				

Appendix Table 3. Analysis of variance for colour of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	3.583	4	0.896	8.345*	0.003	5.99
Within Groups	1.073	10	0.107			
Total	4.656	14				

(level).

Appendix Table 4. Analysis of variance for odour of different full cream powder milk samples

ANOVA					
	df	MS	F calculated	P-value	F tabulated
Between Groups	4	0.176	6.253*	0.009	5.99
Within Groups	10	0.028			
Total	14				

Appendix Table 5. Analysis of variance for appearance of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	0.823	4	0.206	2.830	0.0830	5.99
Within Groups	0.727	10	0.073			
Total	1.549	14				

Appendix Table 6. Analysis of variance for total score of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	9.450	4	2.363	6.142*	0.009	5.99
Within Groups	3.846	10	0.385			
Total	13.297	14				

* Significant (at 1% level).

Appendix Table 7. Analysis of variance for Specific gravity of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	0.000	4	0.000	1.423	0.296	5.99
Within Groups	0.000	10	0.000			
Total	0.000	14				

Appendix Table 8. Analysis of variance for acidity (%) of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	0.002	4	0.000	1.209	0.366	5.99
Within Groups	0.004	10	0.000			
Total	0.005	14				

Appendix Table 9. Analysis of variance for fat (g/100g) of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	9.911	4	2.478	2.737	0.090	5.99
Within Groups	9.053	10	0.905			
Total	18.964	14				

Appendix Table 10. Analysis of variance for protein (g/100g) of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	4.233	4	1.058	1.752	0.215	5.99
Within Groups	6.040	10	0.604			
Total	10.273	14				

Appendix Table 11. Analysis of variance for ash (g/100g) of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	0.623	4	0.156	2.747	0.089	5.99
Within Groups	0.567	10	0.057			
Total	1.189	14				

Appendix Table 12. Analysis of variance for moisture (g/100g) of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	0.438	4	0.110	1.077	0.418	5.99
Within Groups	1.017	10	0.102			
Total	1.455	14				

Appendix Table 13. Analysis of variance for lactose (g/100g) of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	3.978	4	0.994	3.149	0.064	5.99
Within Groups	3.158	10	0.316			
Total	7.136	14				

Appendix Table 14. Analysis of variance for SNF (g/ 100g) of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	5.509	4	1.377	2.251	0.136	5.99
Within Groups	6.119	10	0.612			
Total	11.627	14				

Appendix Table 15. Analysis of variance for TS (g/ 100g) of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	3.556	4	0.889	1.014	0.445	5.99
Within Groups	8.770	10	0.877			
Total	12.327	14				

Appendix Table 16. Analysis of variance for total viable count /g of different full cream powder milk samples

ANOVA						
Source of variation	SS	df	MS	F calculated	P-value	F tabulated
Between Groups	6.250	4	1.563	0.658	0.635	5.99
Within Groups	23.750	10	2.375			
Total	30.000	14				