THE NATIONAL UNIVERSITY OF MALAYSIA

FACULTY OF ENGINEERING AND BUILT ENVIRONMENT

CHEMICAL AND PROCESS ENGINEERING DEPARTMENT

INTEGRATED PROJECT

SEMESTER II

SESSION 2019/2020

PRODUCTION OF BUTTER

GROUP : 1-10

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DECLARATION

We hereby declare that the works in this project are our own except for our own except for quotations and summaries which have been duty acknowledged.

Date: 14 th June 2020 ANG WEN JIN (A173937)

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Besides, we would like to express my feeling of appreciation to all our team members who always gave a full commitment in this project and contribute their effort in this project till the end. We would like to thank to our course member for their help and guidance.

Lastly, we would also like to thank the Department of Chemical and Process Engineering, Faculty of Engineering and Built Environment for providing us experience and knowledge to complete this project. We hope that our integrated project will be beneficial to us in our future and we cannot deny that this project provides us a mountain of knowledge which is essential to us.

ABSTRACT

By doing this integrated project, we need to do a research on the production of butter. To complete this project, we have frequented ourselves to Perpustakaan Tun Sri Lanang to look for some sources. We also get many helpful advices from professors when we faced any obstacles.

Butter which composition are 80-82% milk fat,16-17% of water and 1-2% milk solid. The density of the butter is 911 grams per litre and it exist as pale yellow color. Milk is the key raw material to produce butter via various processes. In the production of butter, there are totally 3 types waste products which are water, buttermilk and skim milk. In this project, we get to determine the global supply and demand of butter. By using the data that we found, we able to find out its plant capacity. The mass balance is calculated by using the plant capacity that I get from the graph. The mass balance and energy were done to ensure the flow rate of the input and output are the same. The process of the manufacturing is being drawn by using Microsoft Visio and each component were labelled in a systematically manner.

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CHAPTER I

1.1 INTRODUCTION

Butter is one of the most highly concentrated forms of fluid milk which produced through a phase inversion of an emulsion. The butter is in solid, waxy textures and different in color from white to deep yellow. Butter was always made form mammals milk and usually cow's milk was used but in Indian subcontinent, water buffalo's milk is used, in the Himalayas, yak's milk is used and in central Asia, sheep's milk is used. There are two methods to produce the butter which is traditional small-scale method and NIZO technique. There are various types of butter such as salt butter, sweet butter, sour butter, and shea butter. Although the way of production not same but the main input is still the same. Butter will remain in solid shape when in a refrigerator and butter will soften to a spreadable when in a room temperature and above. Butter can be divided into four types which are based on their acidity of cream, salt content, end use and MFG practice. The principal constituents of a normal salted butter are fat (80 - 82%), water (15.6 - 17.6%), salt (about 1.2%) as well as protein, calcium and phosphorous (about 1.2%) and it also contains fat-soluble vitamins A, D and E.

1.2 THE USAGES OF BUTTER

Butter plays an essential role in baking process as is adding flavor to bakes goods and makes it become more tender. Some cake batters are leaved, by sugar and creaming butter, which introduces air bubbles into the butter. These bubbles trapped within the butter and it aerates the cookie and makes the butter expand during heating process. Cookies such as shortbread has only water in the butter and they do not have other

source of moisture. Mixing butter into dough especially in preparing pies and tarts, it will help to increase its flakiness.

There is variety of food that can prepared by using butter as one of the ingredients such as Linzer torte, Torpedo dessert and so forth. Due to its low smoke point, butter is not generally used at high temperature or for deep frying. Butter has a rich flavor and creamy texture due to its high concentration of fat. It helps to prevent sticking while adding flavor.

1.3 PHYSICAL AND CHEMICAL PROPERTIES

Substances	Chemical Properties	Physical Properties
Raw milk	-The pH of milk at $25°C$ is in the range 6.5 and 6.7 -One cup of raw milk contains 8 grams of fat -Stable under normal temperatures and pressures.	-Have a milky taste -Specific gravity for milk is 1020-1030 -Freezing point for milk is around $-0.522°C$ -Boiling point is $100.5℃$ -Stable under recommended storage conditions.
Skim	-The pH for skim is 6.7 -No toxicity -Skim milk only have 0.3% fat.	-The colour of skim milk is light yellow. -Boiling point for skim is around $40-45℃$ -Water solubility is ca.700 g/l at 20℃ -Bulk density is ca.500 kg/m3 -Stable under recommended storage conditions.
Cream	-Range pH for cream is 4.70-5.20 -Stable under normal temperatures and pressures. -Cream contain about 35% of fat.	-Slightly sour -The boiling point for cream is $130℃$ -Flash point for cream is $164℉$ -Soluble in water -specific gravity is 1.035
Buttermilk	-The pH for buttermilk is below 4.7 -Not reactive with water. -Butter milk contains only 1% of fat.	-Tangy and bitter taste -Freezing point for buttermilk is $4℃$ -Light cream colour. -Soluble in water. -Stable under normal conditions
Butter	-The pH of butter is around 9 -One cup of butter contains 184 g of fat. -Not reactive under normal conditions. -The chemical stability for butter is stable.	-Butter in water-in-oil emulsion -Various in colour from deep yellow to nearly white -Melting point for butter is $35\text{-}36°C$ -Smoke point for butter is at $150℃$ -Soluble in water

Table 1.1 Physical and Chemical properties for the Substances

1.4 PROCESS DESCRIPTION

Based on our chemical plant, we use continuous buttermaker to produce butter. The raw materials that used to produce butter are raw milk and cream. The continuous buttermaker has four types which are traditional batch churning from 25%-35%. Milk fat cream, continuous flotation churning from 30-50% milk fat cream, the concentration process whereby "plastic" cream at 82% mf. is separated from 35% milk fat cream at 55℃ and then this oil-in-water emulsion cream is inverted to a water-in-oil emulsion butter with no further draining of buttermilk and the anhydrous milkfat process whereby water, SNF, and salt are emulsified into butter oil in a process very similar to margarine manufacture.

1.4.1 SEPARATION PROCESS

Milk and cream are collected from cows or buffalo, goats, camel and mares. Cream is separated from milk. The milk is separated through centrifugal separator device (CS-101). the separator spins dividing the raw milks fat from the rest of the liquid which is known as buttercream and the rest is skim milk. The speed of the device is about 6000 revolutions per minute. The raw milk is separated to raw skim milk and raw cream.

1.4.2 PASTEURIZATION PROCESS

The cream should be sweet which means their pH must greater than 6.6, not rancid, not oxidized, and free from off flavors. The cream is pasteurized at a temperature of 95℃ or above to destroy enzymes and microorganisms. Specially designed plate heat exchangers may be used to minimize physical damage to the fat globules and the uptake of the copper onto the fat globule membrane from the serum can be prevented by avoiding the severe heat treatments. Through pasteurization, pathogenic bacteria, other bacteria and enzymes that could affect the keeping quality can be killed.

1.4.3 RIPENING PROCESS

The cream is ripened to pH 5.5 at 21℃ which enables flavor development to occur. The colder the temperature during ripening, the more the flavor development relative to acid production. After ripening, the cream is cooled to about 7℃ for several hours to allow the fat to harden. The cream is then allowed to warm to at about 10℃ in the warmer weather and 18℃ in cooler weather and is poured into a butter churn.

1.4.4 AGING PROCESS

Before churning, cream is held at cool temperatures to crystallize the butterfat globules. The cream is subjected to a program of controlled cooling designed to give the fat the required crystalline structure. The ripening process usually takes about 12-15 hours. After ripening, the butter is then pumped to the churner. By setting the temperature at 16 ° C, the hardest part of the fat will be fixed in crystal form. The more violent the cooling process, the more fat will be crystallized to form the solid and less liquid fat that can squeezed out of the fat globules during churning process. The crystals bind the liquid fat to their surface by adsorption. After cooling for about 2 hours, most of the hard fat had crystallized and binding little of the liquid fat.

1.4.5 CHURNING PROCESS

After the aging process, butterfat had crystallized and then it undergoes churning process at about 7 ℃ to become butter granules which formed by aggregation of the action of fat globules under the action of air present in the cream. The air in the cream is beaten during churning process and dispersed into small bubbles. This process involved high-speed beaters (CN-101) which speed is around 2800rpm to destabilize the fat emulsion in chilled cream and caused the butter granules formed in few seconds. About 45.2% milk solid is formed during churning process and the rest is called buttermilk.

1.4.6 DRAINING AND WASHING PROCESS

After that, buttermilk and butter granules undergo draining and washing process. By the continuous buttermaker, the buttermilk had drained out continuously through a wire mesh which covers by the perforated cylinder and butter granules were worked in kneading section consists of screw type kneader. The butter was forced to flow through many perforated plates arranged in series to produce a fine dispersion of water in butter. The granules were pressed and kneaded together. After the buttermilk had drained off, the butter is worked to a continuous fat phase containing a finely dispersed water phase to remove any residual buttermilk and milk solids.

1.4.7 WORKING PROCESS

Then, the raw butter undergoes working process, water are added through an opening immediately in front of the perforated plates to adjust the moisture of the butter.The spreadability improved by using vacuum compartments to reduce the air content of the butter.

1.4.8 PACKAGING AND STORAGE PROCESS

For the packaging and storage, the butter was patted into shape and wrapped in waxed paper and then stored in a cool place. The butter became firm after it cooled. Butter can also be frozen to further extend its storage life.

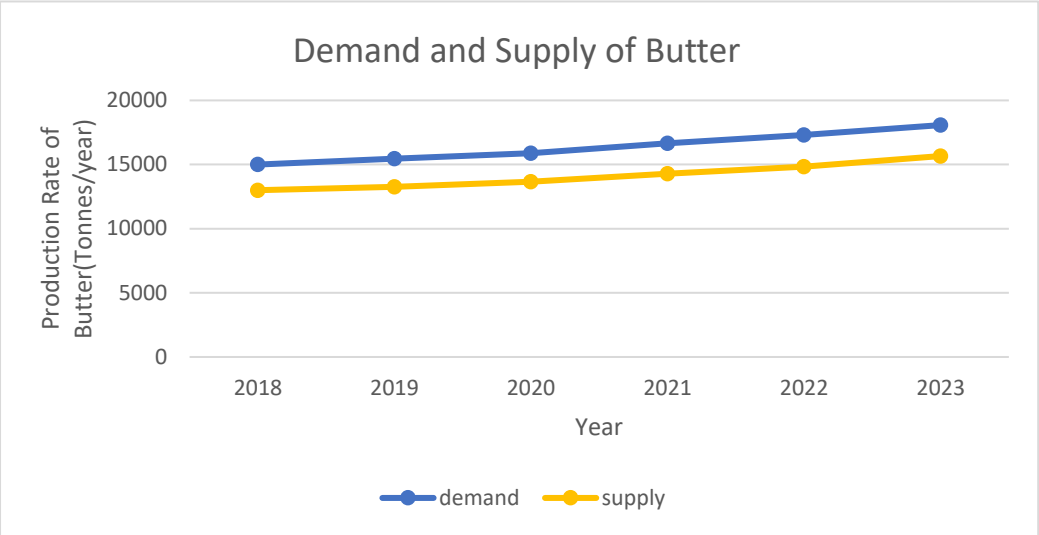
CHAPTER II

ECONOMIC ISSUES OF BUTTER

2.1 SUPPLY AND DEMAND GRAPH FOR BUTTER

During the forecast period,2018-2023 the global butter market is expected to grow at a CAGR of 3.8%. In 2018, the global butter exports expanded by 7.5 % to 917920 tonnes which contributed by New Zealand, the United States of America and India, but those of the European Union declined. The global butter import demand remained strong which include developing and developed countries such as China, United States of America, Egypt Australia, Saudi Arabia and Malaysia. China remained the largest butter importer and its imports grew to 147568 tonnes in 2018 which means that the percentage of growth is about 16.2% due to the demand from an increasingly urbanized population with higher incomes.

Figure 2.1: Graph of global demand and supply of butter



(Dairy and Products Annual,2017)

2.2 FUTURE MARKETING POTENTIAL

Butter market has been segmented on basis of processing which are processed butter and non- processed butter and in 2016, processes butter holds a share of 6%. Butter plays vital role in marketing as it able to use in baking, sauce making, pan frying and cooking. Butter contains milk protein, water and butterfat. Due to its wide application in cooking and baking, the demand on it is high and butter has a huge market potential. The rise in home-baking and product innovation in developed countries become major driver for the market of butter. The top manufacturers of butter with the market share, production revenue and include Dairy farmers of America, Fonterra and so forth. In 2018, the largest region in the milk and butter manufacturing market- Asia Pacific which worth $126.9 billion, accounting for 45.3% of the global milk and butter manufacturing market. The second largest region is Western Europe at 22.3% and followed by North America at 17.0% respectively.

According to the latest research made by IMARC, the global table butter market grew of around 3.1% from the year 2009 until 2016 and finally reaching a volume of 4.6 Million Metric Tons in 2016.In a report from an analysis in some regions. We found that Asia is the biggest producer of butter followed by Western Europe, North America,

Oceania and other regions. (“Table Butter Market | Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2017-2022” n.d.)

The main consumer of butter is France with a per capita consumption of 8.2 kg, and it followed by Denmark with a per capita consumption of 6.4 kg in the world. The third top consumer is Iceland with 6 kg and followed by Czech Republic with 5.4 kg while Switzerland closes the top five with 5.2 kg. New Zealand is the only country with a per capita consumption of above 5 kg. (“Countries Who Consume the Most Butter - WorldAtlas.com” n.d.)

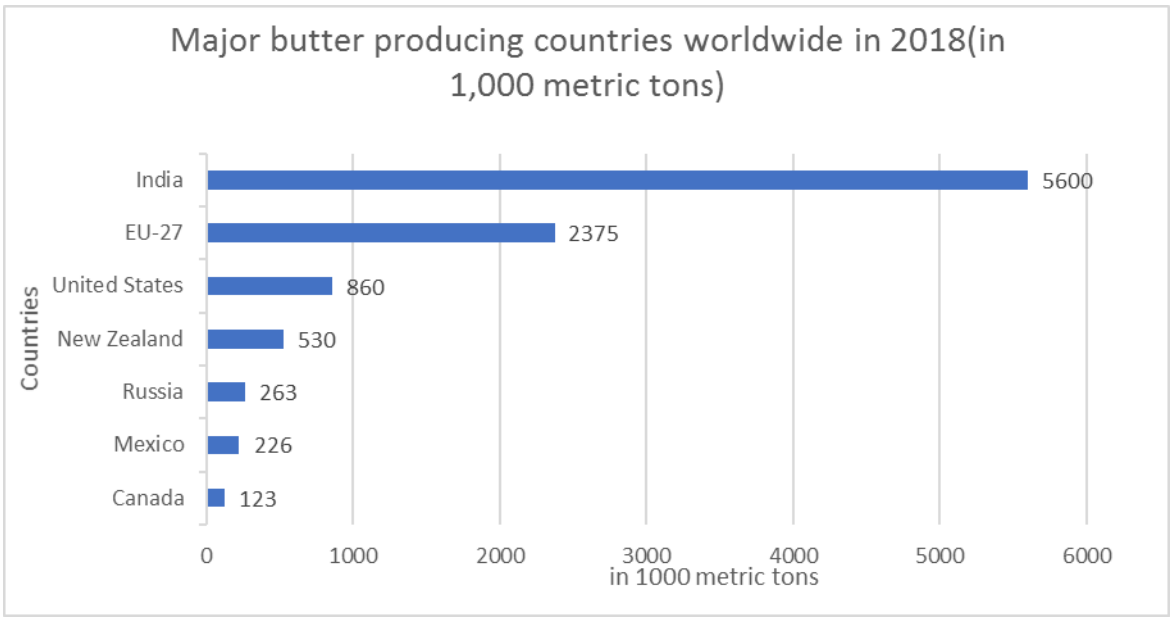


Figure 2.2: Major butter producing countries worldwide
(Source: Statista,2019)

2.3 MARKET PRICE OF BUTTER

Prices for butter and non-fat dry milk (NFDM) have posted stellar year-over-year gains so far this year and NFDM (NFDM) prices averaged 99.22 cents per pound in February versus 72.17 cents a year earlier. Butter prices in February averaged $2.2659 per pound, 14 cents higher than February 2017. In United States, butter usage during 2018 was up 2% from the previous year, but finished the year strongly, gaining 6% from the last quarter of 2017 based on calculations by USDA’s Economic Research Service. In

January, the butter production was up 4% from a year earlier, but usage was good enough to keep domestic inventories from building as much as they usually do during January. Table below shows the price of butter in year 2018 in Western Europe.

Table 2.1: Price of Butter in Western Europe

Month	Price of butter in Western Europe in 2018 per ton
Jan	4.988
Feb	5.263
Mar	6.000
Apr	6.544
May	7.019
Jun	7.163
Jul	6.688
Aug	6.513
Sept	6.406
Oct	5.544
Nov	5.094
Dec	4.963

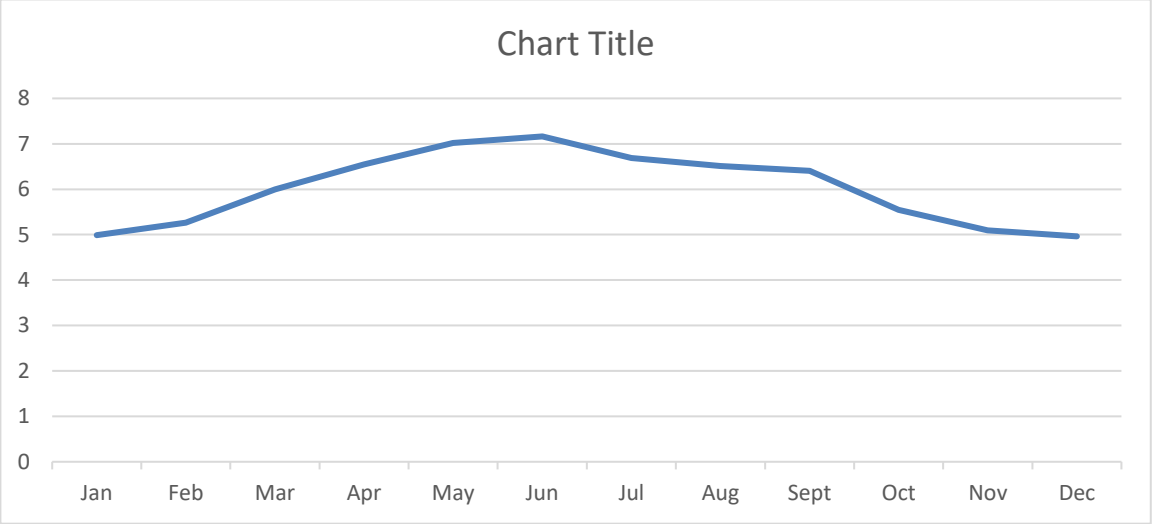


Figure 2.3 Price of Butter in 2019

Source: ("CLAL - Butter, International Market - Western Europe" n.d.)

2.4 LIST OF EXISTING COMPANY

The companies that produce butter are Tatura, Arla and Dairy Crest. It is predicted that that the capacity of the world butter by 2023 will reach around 18,075 millions tons /year. The list of butter production companies are shown in Table 2.4.1.

Table 2.2 List of Butter Production Company

Country	Company	Capacity (tonnes/year)
Australia	Tatura Milk Industries Ltd.	8000
Sweden	Arla Foods	76000
United Kingdom	Dairy Crest Group plc	56000
	Ornua Foods Ltd.	4000
India	AGRA	20000
Netherlans	FrieslandCampina N. V.	41666
New Zealands	Anchor	290000

2.5 PRODUCTION RATE AND PLANT CAPACITY

Due to the various usage of milk in many sectors especially in production of butter, the high and increasing demand of butter is expected. From the data obtained in Figure2.1, the supply and demand graph show positive trends. This indicates that the production of butter is constantly increased from year to year. Thus, in the coming year 2019, the production rate of plant is estimated as below:

Demand–Supply = 15450,000 tonne/year–13273,000 tonne/year

=,177,000tonne/year

=2,177kilotonne/year

Thus, by calculating in the coming year 2020, the proposed butter demand will be 2,177 kilotonne /year more than the supply. Which means the production of butter is lower than the global demand of butter.

Production time a year =350daysx24hours

= 8400hours

Plant capacity =0.02 x 2177kilotonne/year

=43.54kilotonne/8400hours

=5183kg/hr

Therefore, our plant capacity is set to produce 43.54kilotonne/year, which contribute 2% to the global demand.

CHAPTER III

ENVIRONMENTAL AND SAFETY ISSUES

3.1 ENVIRONMENTAL ISSUES

3.1.1 Waste By-products

Skim milk, buttermilk and whey are the waste product that be generated from the production of butter. For every pound of butter, it will produce about 3 pounds of buttermilk, 15-20 pounds of skim milk. The production of butter may probably cause the global warming potential, eutrophication potential and acidification potential. The land use for butter is about twice compared to margarine because more land is needed to produce the feed for dairy cows which is about 8.5 square metres per 500 grammes (m2/500g). The production of butter uses more water which is about 5,553 litres of water to produce 1 kg of butter and it also cause the air pollution problem to our environment. (“The Impact/Footprint of Producing & Eating Butter & Margarine - Better Meets Reality” n.d.)

3.1.2 Waste Treatment

Excess whey, skim milk and buttermilk can be reused to produce commercial industrial products in the hope to return farm patrons and eliminate legal problems. According to Utilization of By-Product of the Dairy by Henry E. Alvord, C.E., by feeding domestic animals of various kinds with skim milk-waste by-product from the production of butter, we will gain the most profitable use as the experiment conducted successfully

proved that skim milk makes rapid growth of the domestic animals. Besides, the waste water of the production of the butter is treated by adjusting pH and by using strong coagulant chemistry to break any emulsions by cleaning agents and sanitizers. The chemicals are added to cause precipitation and coagulation. The predominant by-product should be processed into high value products like skim milk powder (SMP), buttermilk powder (BMP), whey powder, whey protein concentrates and casein rather than being dumped as waste. Hot water is suitable to be used to remove the residue butterfat from cream processing and butter making equipment. The temperature of the water must not be too high (below 65°C). Whey should be dried where possible. To maximize the production of butter, a waste management plan should be prepared according to the procedures outlined in Waste Minimisation Assessment.

3.1.3 Environmental Quality Acts in Malaysia

The dairy industry contributes many negative impacts to our environment. To cope with these impacts, the Malaysian Government has passed some important environmental laws and policies such as Environmental Quality (Clean Air) Regulations, Environmental Quality (Scheduled Wastes) Regulations 2005, Environmental Quality Act 1974, Environmental Quality (Amendment) Act 1998 and so forth. Environmental Quality (Scheduled Wastes) Regulations 2005 provide for the disposal, treatment, management, storage and transport of scheduled wastes. Environmental Quality Act 1974 is an act relating to the prevention, abatement, control of pollution and enhancement of the environment and for purposes connected therewith. This means that any pollution caused during the operation of the plant has to be within the range set by the standards in the national law. The waste products that need to treated have to be inspected first before released to the environment to ensure they follow the standard set by the Ministry of Environment. To encourage proper industrial waste management, there are a few incentives are currently available which includes pioneer status incentive for 5 years to companies which are principally engaged in an integrated operation for the storage, treatment and disposal of toxic and hazardous wastes.

3.2 SAFETY ISSUE ON PRODUCT ANDD RAW MATERIALS

3.2.1 Properties of Raw Materials

Table 3.1 Properties of Materials

Materials	Explanation
Butter	A creamy white ivory solid with a light odor, not flammable and toxic. This product is not reactive. Hazardous reaction will not occur under conditions of normal storage and use.
Milk protein	Light yellow to brown transparent liquid. It is under normal conditions, but may emit noxious fumes of CO.
Salt	Non-combustible. Hazardous polymerization will not occur. Over exposure may produce irritation of the mucous membrane, nose, throat, coughing and shortness of breath.
Carotene	A crystalline solid. Cause serious eye irritation. It may be harmful to inhalation or skin absorption. May be combustible in high temperature.

*Source: Chemical Book 2017)

3.2. Handling Methods and Storage

The handling methods and storage of butter is important to provide general information to persons who manufacture, consume and handle butter. The table below shows that the handling and storage precautions of butter.

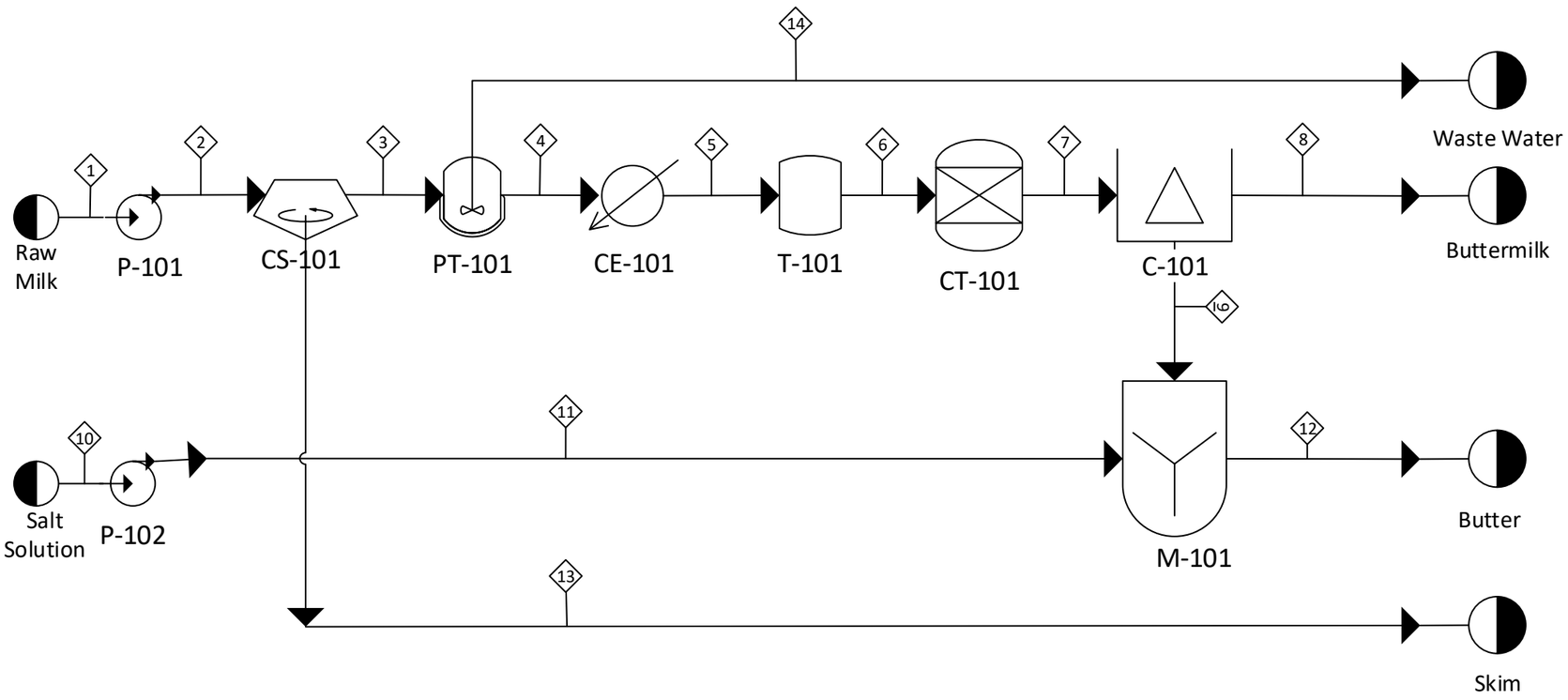
Table 3.2 Handling Methods and Storage

Handling Precaution	**Storage Precaution**
Butter should be handled with good industrial hygiene and safety practice by wearing protective gloves or clothing.	Keep container tightly closed and store in a cool, dry and well-ventilated place.
Raw milk is usually pasteurized by low 40°F temperature pasteurization in which milk is to 145°F or higher for at least 30 minutes high temperature pasteurization,161°F for 15 minutes and quickly cooled.	Store the butter at the temperature below or below to protect the quality of milk. Heated This temperature should be maintained while warehousing, distribution, delivery.
Consult the material safety data sheet.	Avoid butter exposed to light and strong odour Avoid extremes of temperature.

Do not breathe dust, fume, gas or spray. Wash face, hands and any exposed skin thoroughly after handling. Wash contaminated clothing before reuse.	Keep receptacle tightly sealed when not in used.

Source: (“Safe Handling of Milk & Dairy Products | Home & Garden Information Center” n.d.)

CS-101 Centrifugal Separator CE-101 Cooler CT-101 Crystalizer PT-101 Pasteurizer T-10 Storage Tank
C-101 Chunner M-101 Mixer P-101 Pump P-102 Pump



Stream	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Temperature(°C)	28	28	28	95	33	21	16	7	7	28	28	28	28	95
pressure(bar)	1.02	1	5	1	1	1.2	1.3	1.5	1.5	1.02	1.02	1	5	6
Phase	L	L	S/L	S/L	S/L	S/L	S/L	L	S	L	L	S	L	G
Water	100878.3	100878.3	8516.79	5413.95	5413.95	5413.95	5413.95	4786.49	627.46	142.58	142.58	770.04	92361.57	3102.81
Fat	4638.08	4638.08	3994.81	3994.81	3994.81	3994.81	3994.81	107.56	3887.25	0	0	3887.25	643.27	0
Protein	3478.56	3478.56	265.01	265.01	265.01	265.01	265.01	161.35	103.66	0	0	103.66	3213.55	0
Lactose	5797.61	5797.61	372.56	372.56	372.56	372.56	372.56	268.9	103.66	0	0	103.66	5425.05	0
Mineral	1159.52	1159.52	158.29	158.29	158.29	158.29	158.29	53.78	104.51	213.88	213.88	318.39	1001.23	0
Total Flowrate(kg/h)	115952.1	115952.1	13307.43	10204.62	10204.62	10204.62	10204.62	5378.08	4826.54	356.46	356.46	5183	102644.7	3102.81

UNIVERSITI KEBANGSAAN MALAYSIA
The National University of Malaysia

Title: Production of Butter

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Input Stream Label

Output

Date : 14 JUNE 2020

CHAPTER IV

4.1 MATERIAL BALANCE

Plant capacity for our plant covers the capacity of Malaysia's production of butter throughout the year which is 55,020 tonne/year.

F = (43540 tonnes /year x 1000 kg/tonne) / (350 days x 24 hours)

= 5183 kg/hr

Mass balance is used to compare the inputs and outputs of the process so that the mass that enter the system must be equal to the mass that leave the system. By calculating the mass balance, we able to make sure that there is no mass loss during the process. In the material balance equation, we used plant capacity to find the initial flow rate of milk.

Mass Balance Calculation

The annotations that are used:

Water : W

Fat : F

Protein : P

Lactose : L

Mineral : M

4.1.1 Centrifugal separator CS-101

Figure 5.3 shows a separator where the milk separated into cream (stream 3) and skim milk (stream 13) as a waste product.

F_2 = 115952.1 kg/h

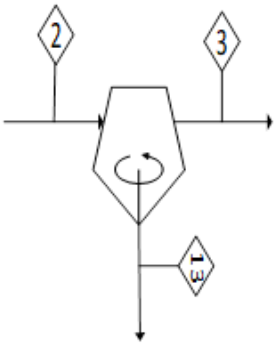
F_{2W} = 100878.33 kg/h

F_{2F} = 4638.08 kg/h

F_{2P} = 3478.56 kg/h

F_{2L} = 5797.61 kg/h

F_{2M} = 1159.52 kg/h



F_3 = 13307.43 kg/h

F_{3W} = 8516.76 kg/h

F_{3F} = 3999.81 kg/h

F_{3P} = 265.01 kg/h

F_{3L} = 372.56 kg/h

F_{3M} = 158.29 kg/h

F_{13} = 102644.67 kg/h

F_{13W} = 92361.57 kg/h

F_{13F} = 643.27 kg/h

F_{13P} = 3213.55 kg/h

F_{13L} = 5425.05 kg/h

F_{13M} = 1001.23 kg/h

Figure 4.1 Centrifugal Separator CS-101

Table 4.1 Mass Fraction and Mass Flow Rate of Each Component in Centrifugal Separator CS-101

	Stream 2		Stream 13		Stream 3	
component	w	F(kg/h)	w	F(kg/h)	W	F(kg/h)
Fat	0.040	4638.08	0.006	643.27	0.300	3994.81
Water	0.870	100878.33	0.900	92361.57	0.640	8516.76
Protein	0.030	3478.56	0.031	3213.55	0.020	265.01
Lactose	0.050	5797.61	0.053	5425.05	0.028	372.56
Mineral	0.010	1159.52	0.010	1001.23	0.012	158.29
Total	1.000	115952.1	1.000	102644.67	1.000	13307.43

4.1.2 Pasteurizer PT-101

Figure 5.4 shows that the butter cream fed into pasteurizer to kill bacteria and produced evaporated water. The cream (stream 3) enters the pasteurizer and some water vapor leaves from stream 14 and the remaining cream enters stream 4.

F_{14} = 3102.81 kg/h

F_{14W} = 3102.81 kg/h

F_{14F} = 0 kg/h

F_{14P} = 0 kg/h

F_{14L} = 0 kg/h

F_{14M} = 0 kg/h

F_3 = 13307.43 kg/h

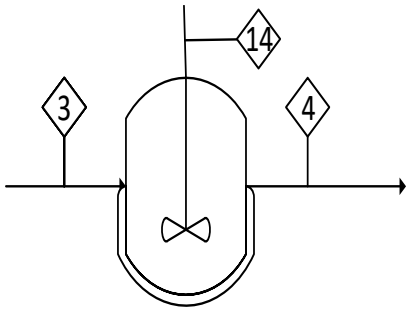
F_{3W} = 8516.76 kg/h

F_{3F} = 3994.81 kg/h

F_{3P} = 265.01 kg/h

F_{3L} = 372.56 kg/h

F_{3M} = 158.29 kg/h



F_4 = 10204.62 kg/h

F_{4W} = 5413.95 kg/h

F_{4F} = 3994.81 kg/h

F_{4P} = 265.01 kg/h

F_{4L} = 372.56 kg/h

F_{4M} = 158.29 kg/h

Figure 4.2 Pasteurizer P-101

Table 4.2 Mass Fraction and Mass Flow Rate of Each Component in pasteurizer P-101

	Stream 3		Stream 14		Stream 4	
component	W	F(kg/h)	w	F(kg/h)	W	F(kg/h)
Fat	0.300	3994.81	0	0	0.391	3994.81
Water	0.640	8516.76	1.000	3102.81	0.531	5413.95
Protein	0.020	265.01	0	0	0.026	265.01
Lactose	0.028	372.56	0	0	0.037	372.56
Mineral	0.012	158.29	0	0	0.015	158.29
total	1.000	13307.43	1.000	3102.81	1.000	10204.62

4.1.3 Churner C-101

Figure 5.5 shows butter cream fed into churner to produced butter granules (stream 9) and buttermilk (stream 8).

F_7 = 10204.62 kg/h

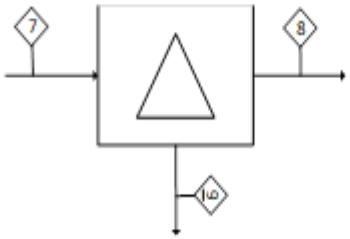
F_{7W} = 5413.95 kg/h

F_{7F} = 3994.81 kg/h

F_{7P} = 265.01 kg/h

F_{7L} = 372.56 kg/h

F_{7M} = 158.29 kg/h



F_8 = 5378.08 kg/h

F_{8W} = 4786.49 kg/h

F_{8F} = 107.56 kg/h

F_{8P} = 161.35 kg/h

F_{8L} = 268.9 kg/h

F_{8M} = 53.78 kg/h

F_9 = 4826.54 kg/h

F_{9W} = 627.46 kg/h

F_{9F} = 3887.25 kg/h

F_{9P} = 103.66 kg/h

F_{9L} = 103.66 kg/h

F_{9M} = 104.51 kg/h

Figure 4.3 Churner C-101

Table 4.3 Mass Fraction and Mass Flow Rate of Each Component in Churner C-101

	Stream 7		Stream 8		Stream 9	
component	w	F(kg/h)	w	F(kg/h)	W	F(kg/h)
Fat	0.391	3994.81	0.020	107.56	0.806	3887.25
Water	0.531	5413.95	0.890	4786.49	0.130	627.46
Protein	0.026	265.01	0.030	161.35	0.021	103.66
Lactose	0.037	372.56	0.050	268.9	0.021	103.66
Mineral	0.015	158.29	0.010	53.78	0.022	104.51
Total	1.000	10204.62	1.000	5378.08	1.00	4826.54

4.1.4 Mixer M-101

Figure 5.7 shows water (stream 11) and butter granules (stream 9) fed into mixer and formed butter (stream 12) as the final product.

$F_9 = 4826.54$ kg/h

$F_{9W} = 627.46$ kg/h

$F_{9F} = 3887.25$ kg/h

$F_{9P} = 103.66$ kg/h

$F_{9L} = 103.66$ kg/h

$F_{9M} = 104.51$ kg/h

$F_{11} = 356.46$ kg/h

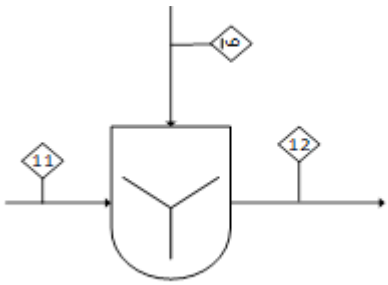
$F_{11W} = 142.58$ kg/h

$F_{11F} = 0$ kg/h

$F_{11P} = 0$ kg/h

$F_{11L} = 0$ kg/h

$F_{11M} = 213.88$ kg/h



$F_{12} = 5183$ kg/h

$F_{12W} = 770.04$ kg/h

$F_{12F} = 3887.25$ kg/h

$F_{12P} = 103.66$ kg/h

$F_{12L} = 103.66$ kg/h

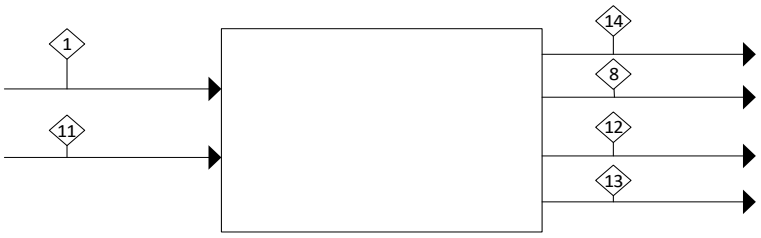
$F_{12M} = 318.39$ kg/h

Figure 4.5 Mixer M-101

Table 4.5 Mass Fraction and Mass Flow Rate of Each Component in Mixer M-101

	Stream 9		Stream 11		Stream 12	
component	w	F(kg/h)	w	F(kg/h)	W	F(kg/h)
Fat	0.806	3887.25	0	0	0.750	3887.25
Water	0.130	627.46	0.400	142.58	0.149	770.04
Protein	0.021	103.66	0	0	0.020	103.66
Lactose	0.021	103.66	0	0	0.020	103.66
Mineral	0.022	104.51	0.600	213.88	0.061	318.39
Total	1.000	4826.54	1.000	356.46	1.000	5183

4.1.5 Overall mass balance for whole processes



$F_1 + F_{11} = F_{14} + F_{12} + F_{13} + F_{18}$

115952.1 + 356.46= 3102.81 + 5183 + 102644.67 + 5378.08

116308.56 = 116308.56 (BALANCED)

4.2 ENERGY BALANCE

Energy balance is the arithmetic of balancing of energy inputs versus outputs for an object, reactor, or other unit processes. During the reaction, energy balance is used to determine the heat released or absorbed. The reaction is endothermic if heat is absorbed and is exothermic if the heat is released. The energy balances are used to quantify the energy used or produced by a system.

The law of conversion of energy states that energy can neither be created nor destroyed; it can only be changed from one form to another or transferred from one body to another. The calculation of energy balance is to determine the heat change of the unit process.

The assumptions used in the calculations are as follow:

1. The flow in the unit processes are in steady state.

2. The reference temperature is fixed at 25℃.

3. There is no potential energy, kinetic energy and work done by the system.

Table 5.1: Specific heat capacity of each component (J $kg^{-1}K^{-1}$ except water in the unit J $mol^{-1}K^{-1}$)

Component	A	B	C	D
Water	32.24	0.1923x10-2	1.055 x 10-5	-3.595 x 10+9
Protein	2.0082 x 103	1.2089	-1.3129 x 10-3	-
Fat	1.9842 x 103	1.4733	-4.8008 x 10-3	-
Ash	1.0926 x 103	1.8896	-3.6817 x 10-3	-
Lactose	1.5488 x 103	1.9625	-5.9399 x 10-3	-

4.2.1 Energy Balance at Pasteurizer (PT-101)

Figure 5.4 shows that the butter cream fed into pasteurizer to kill bacteria and produced evaporated water. The cream (stream 3) enters the pasteurizer and some water vapor leaves from stream 14 and the remaining cream enters stream 4.

F_{14} = 3102.81 kg/h

F_{14W} = 3102.81 kg/h

F_{14F} = 0 kg/h

F_{14P} = 0 kg/h

F_{14L} = 0 kg/h

F_{14M} = 0 kg/h

F_3 = 13307.43 kg/h

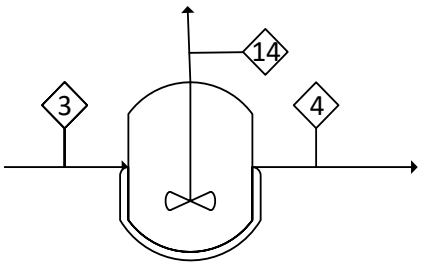
F_{3W} = 8516.76 kg/h

F_{3F} = 3994.81 kg/h

F_{3P} = 265.01 kg/h

F_{3L} = 372.56 kg/h

F_{3M} = 158.29 kg/h



F_4 = 10204.62 kg/h

F_{4W} = 5413.95 kg/h

F_{4F} = 3994.81 kg/h

F_{4P} = 265.01 kg/h

F_{4L} = 372.56 kg/h

F_{4M} = 158.29 kg/h

Feed Enthalpy, ΔH = $\int_{T1}^{T2} Cp\ dT$

Temperature is from T_1= 298K to T_2= 301K

Stream 3:

Lactose

$\Delta H_L = \int_{298}^{301} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T^2 \, dT$

= 0.165 kJ/kg

Protein

$\Delta H_P = \int_{298}^{301} 2.0082 \times 10^{3} + (1.2089)\, T + (-1.3129 \times 10^{-3})\, T^2 \, dT$

= -220.12 kJ/kg

Fat

$\Delta H_F = \int_{298}^{301} 1.984 \times 10^{3} + (1.4733)\, T + (-4.8008 \times 10^{-3})T^2 \, dT$

= -185.15 kJ/kg

Water

$\Delta H_W = \int_{298}^{301} 32.24 + (0.1923 \times 10^{-2})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3 \, dT$

= 0.100997 kJ/mol

$= 5.61 \times 10^{-6}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{301} 1.0926 \times 10^{3} + 1.8896T + (-3.6817 \times 10^{-3})T^2 \, dT$

= -126.14 kJ/kg

Product Enthalpy, $\Delta H = \int_{T1}^{T2} Cp \, dT$

Temperature is from T_1=298 K to T_2= 368K

Stream 14:

Water

$\Delta H_W = \int_{298}^{368} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3 \, dT$

= 2.374 kJ/mol

=1.32× 10^{-4} kJ/kg

Stream 4:

Lactose

$\Delta H_L = \int_{298}^{368} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= -0.531 kJ/kg

Protein

$\Delta H_P = \int_{298}^{368} 2.0082 \times 10^{3} + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

= 158.53 kJ/kg

Fat

$\Delta H_F = \int_{298}^{368} 1.9842 \times 10^{3} + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

= 135.82 kJ/kg

Water

$\Delta H_W = \int_{298}^{368} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\,dT$

= 2.374 kJ/mol

=1.32× 10^{-4} kJ/kg

Mineral

$\Delta H_M = \int_{298}^{368} 1.0926 \times 10^{3} + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

= 91.85 kJ/kg

Protein = $H_{4p}F_{4p} - H_{3p}F_{3p}$

= 100346.04 kJ/h

Fat $= H_{4F}F_{4F} - H_{3F}F_{3F}$

$= 1282214.16$ kJ/h

Lactose $= H_{4L}F_{4L} - H_{3L}F_{3L}$

$= -259.3$ kJ/h

Water $= H_{14W}F_{14W} + H_{4W}F_{4W} - H_{3W}F_{3W}$

$= 1.0766$ kJ/h

Mineral $= H_{4M}F_{4M} - H_{3M}F_{3M}$

$= 34505.64$ kJ/h

Total $= H_p + H_F + H_L + H_W + H_M$

$= 1416807.62$ kJ/h (endothermic, since it is positive)

4.2.2 Energy Balance at Cooler (CE-101)

The temperature is reduced from 95°C unitl reached 33°C for cream to undergo ripening process.

$F_4 = 10204.62$ kg/h

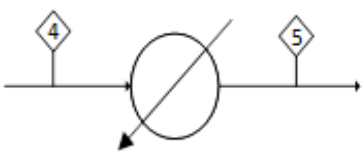
$F_{4W} = 5413.95$ kg/h

$F_{4F} = 3994.81$ kg/h

$F_{4P} = 265.01$ kg/h

$F_{4L} = 372.56$ kg/h

$F_{4M} = 158.29$ kg/h



$F_5 = 10204.62$ kg/h

$F_{5W} = 5413.95$ kg/h

$F_{5F} = 3994.81$ kg/h

$F_{5P} = 265.01$ kg/h

$F_{5L} = 372.56$ kg/h

$F_{5M} = 158.29$ kg/h

Feed Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\ dT$

Temperature is from T_1= 298K to T_2= 368K

Stream 4:

Lactose

$\Delta H_L = \int_{298}^{368} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= -0.531 kJ/kg

Protein

$\Delta H_P = \int_{298}^{368} 2.0082 \times 10^{3} + (1.2089)\ T + (-1.3129 \times 10^{-3})\ T^2\ dT$

= 158.52 kJ/kg

Fat

$\Delta H_F = \int_{298}^{368} 1.984 \times 10^{3} + (1.4733)\ T + (-4.8008 \times 10^{-3})T^2\ dT$

= 135.82 kJ/kg

Water

$\Delta H_W = \int_{298}^{368} 32.24 + (0.1923 \times 10^{-2})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\ dT$

= 2.374 kJ/mol

$=1.32 \times 10^{-4}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{368} 1.0926 \times 10^{3} + 1.8896T + (-3.6817 \times 10^{-3})T^2\ dT$

= 91.845 kJ/kg

Product Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\ dT$

Temperature is from T_1=298 K to T_2= 306 K

Stream 5:

Lactose

$\Delta H_L = \int_{298}^{306} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= 0.41 kJ/kg

Protein

$\Delta H_P = \int_{298}^{306} 2.0082 \times 10^{3} + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

= 18.03 kJ/kg

Fat

$\Delta H_F = \int_{298}^{306} 1.9842 \times 10^{3} + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

= 15.93 kJ/kg

Water

$\Delta H_W = \int_{298}^{306} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\,dT$

= 0.2694 kJ/mol

$= 1.497 \times 10^{-5}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{306} 1.0926 \times 10^{3} + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

= 10.62 kJ/kg

Protein = $H_{5p}F_{5p} - H_{4p}F_{4p}$

= -37231.26 kJ/h

Fat = $H_{5F}F_{5F} - H_{4F}F_{4F}$

= -478937.77 kJ/h

Lactose = $H_{5L}F_{5L} - H_{4L}F_{4L}$

= 350.58 kJ/h

Water = $H_{5w}F_{5W} - H_{4W}F4_W$

= -0.629 kJ/h

Mineral = $H_{5M}F_{5M} - H_{4M}F_{4M}$

= -12857.11 kJ/h

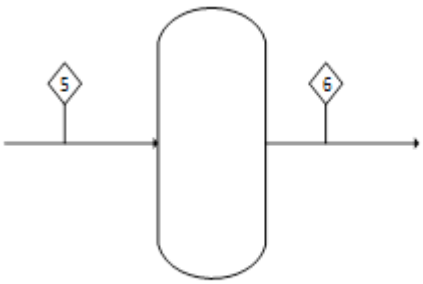
Total = $H_p + H_F + H_L + H_W + H_M$

= -528676.2 kJ/h (exothermic, since it is negative)

4.2.3 Energy balance at Storage Tank (T-101)

The ripening process occurs at storage which pH 5.5 at 21°C to enable flavor development to occur. The cream from cooler (stream 5) will then enter crystallizer (stream 6).

F_5 = 10204.62 kg/h
F_{5W} = 5413.95 kg/h
F_{5F} = 3994.81 kg/h
F_{5P} = 265.01 kg/h
F_{5L} = 372.56 kg/h
F_{5M} = 158.29 kg/h



F_6 = 10204.62 kg/h
F_{6W} = 5413.95 kg/h
F_{6F} = 3994.81 kg/h
F_{6P} = 265.01 kg/h
F_{6L} = 372.56 kg/h
F_{6M} = 158.29 kg/h

Feed Enthalpy, ΔH = $\int_{T1}^{T2} Cp\ dT$

Temperature is from T_1= 298K to T_2= 306K

Stream 5:

Lactose

$\Delta H_L = \int_{298}^{306} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= 0.41 kJ/kg

Protein

$\Delta H_P = \int_{298}^{306} 2.0082 \times 10^{3} + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

= 18.03 kJ/kg

Fat

$\Delta H_F = \int_{298}^{306} 1.9842 \times 10^{3} + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

= 15.93 kJ/kg

Water

$\Delta H_W = \int_{298}^{306} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\,dT$

= 0.2694 kJ/mol

$= 1.497 \times 10^{-5}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{306} 1.0926 \times 10^{3} + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

= 10.62 kJ/kg

Product Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\,dT$

Temperature is from T_1=298 K to T_2= 294 K

Stream 6:

Lactose

$\Delta H_L = \int_{298}^{294} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= -0.242 kJ/kg

Protein

$\Delta H_P = \int_{298}^{294} 2.0082 \times 10^3 + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

$= -9.004$ kJ/kg

Fat

$\Delta H_F = \int_{298}^{294} 1.9842 \times 10^3 + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

$= -7.998$ kJ/kg

Water

$\Delta H_W = \int_{298}^{294} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\,dT$

$= -0.1346$ kJ/mol

$= -7.478 \times 10^{-6}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{294} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

$= -5.32$ kJ/kg

Protein = $H_{6p}F_{6p} - H_{5p}F_{5p}$

$= -7172.23$ kJ/h

Fat = $H_{6F}F_{6F} - H_{5F}F_{5F}$

$= -95587.82$ kJ/h

Lactose = $H_{6L}F_{6L} - H_{5L}F_{5L}$

$= -242.91$kJ/h

Water = $H_{6W}F_{6W} - H_{5W}F_{5W}$

= -0.121 kJ/h

Mineral = $H_{6M}F_{6M} - H_{5M}F_{5M}$

= -2508.9kJ/h

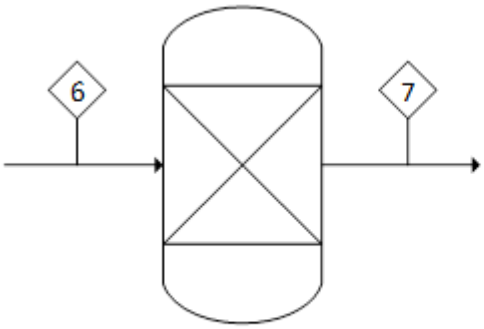
Total = $H_p + H_F + H_L + H_W + H_M$

= -105511.98kJ/h (exothermic, since it is negative)

4.2.4 Energy Balance at Crystallizer (CT-101)

Before churning, cream (stream 6) is held at cool temperatures 7°C to crystallize the butterfat globules.

F_6 = 10204.62 kg/h
F_{6W} = 5413.95 kg/h
F_{6F} = 3994.81 kg/h
F_{6P} = 265.01 kg/h
F_{6L} = 372.56 kg/h
F_{6M} = 158.29 kg/h



F_7 = 10204.62 kg/h
F_{7W} = 5413.95 kg/h
F_{7F} = 3994.81 kg/h
F_{7P} = 265.01 kg/h
F_{7L} = 372.56 kg/h
F_{7M} = 158.29 kg/h

Feed Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\ dT$

Temperature is from T_1= 298K to T_2= 294K

Stream 6:

Lactose

$\Delta H_L = \int_{298}^{294} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= -0.242 kJ/kg

Protein

$\Delta H_P = \int_{298}^{294} 2.0082 \times 10^3 + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

$= -9.004$ kJ/kg

Fat

$\Delta H_F = \int_{298}^{294} 1.9842 \times 10^3 + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

$= -7.998$ kJ/kg

Water

$\Delta H_W = \int_{298}^{294} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3 dT$

$= -0.1346$ kJ/mol

$= -7.478 \times 10^{-6}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{294} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

$= -5.32$ kJ/kg

Product Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\,dT$

Temperature is from T_1=298 K to T_2= 289 K

Stream 7:

Lactose

$\Delta H_L = \int_{298}^{289} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

$= -0.579$ kJ/kg

Protein

$\Delta H_P = \int_{298}^{289} 2.0082 \times 10^3 + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

$= -20.25$ kJ/kg

Fat

$\Delta H_F = \int_{298}^{289} 1.9842 \times 10^3 + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

$= -18.03$ kJ/kg

Water

$\Delta H_W = \int_{298}^{289} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\,dT$

$= -0.3026$ kJ/mol

$= -1.68 \times 10^{-5}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{289} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

$= -11.97$ kJ/kg

Protein = $H_{7p}F_{7p} - H_{6p}F_{6p}$

$= -2980.3$ kJ/h

Fat = $H_{7F}F_{7F} - H_{6F}F_{6F}$

$= -40075.92$ kJ/h

Lactose = $H_{7L}F_{7L} - H_{6L}F_{6L}$

$= -125.56$ kJ/h

Water = $H_{7W}F_{7W} - H_{6W}F_{6W}$

$= -0.05$ kJ/h

Mineral = $H_{7M}F_{7M} - H_{6M}F_{6M}$

$= -1052.63$ kJ/h

Total = $H_p + H_F + H_L + H_W + H_M$

= -44234.46 kJ/h (exothermic, since it is negative)

4.2.5 Energy Balance at Churner (C-101)

About 45.2% milk solid (stream 9) is formed during churning process and the rest is called buttermilk (stream 8).

F_7 = 10204.62 kg/h

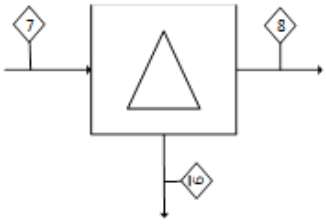
F_{7W} = 5413.95 kg/h

F_{7F} = 3994.81 kg/h

F_{7P} = 265.01 kg/h

F_{7L} = 372.56 kg/h

F_{7M} = 158.29 kg/h



F_8 = 5378.08 kg/h

F_{8W} = 4786.49 kg/h

F_{8F} = 107.56 kg/h

F_{8P} = 161.35 kg/h

F_{8L} = 268.9 kg/h

F_{8M} = 53.78 kg/h

F_9 = 4826.54 kg/h

F_{9W} = 627.46 kg/h

F_{9F} = 3887.25 kg/h

F_{9P} = 103.66 kg/h

F_{9L} = 103.66 kg/h

F_{9M} = 104.51 kg/h

Feed Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\ dT$

Temperature is from T_1= 298K to T_2= 280K

Stream 7:

Lactose

$\Delta H_L = \int_{298}^{289} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= -0.579 kJ/kg

Protein

$\Delta H_P = \int_{298}^{289} 2.0082 \times 10^3 + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

$= -20.25$ kJ/kg

Fat

$\Delta H_F = \int_{298}^{289} 1.9842 \times 10^3 + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

$= -18.03$ kJ/kg

Water

$\Delta H_W = \int_{298}^{289} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\,dT$

$= -0.3026$ kJ/mol

$= -1.68 \times 10^{-5}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{289} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

$= -11.97$ kJ/kg

Product Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\,dT$

Temperature is from T_1=298 K to T_2= 280 K

Stream 8:

Lactose

$\Delta H_L = \int_{298}^{280} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

$= -1.28$ kJ/kg

Protein

$\Delta H_P = \int_{298}^{280} 2.0082 \times 10^3 + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

$= -40.46$ kJ/kg

Fat

$\Delta H_F = \int_{298}^{280} 1.9842 \times 10^3 + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

= -36.16 kJ/kg

Water

$\Delta H_W = \int_{298}^{280} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3 \, dT$

= -0.6046 kJ/mol

= -3.36× 10^{-5} kJ/kg

Mineral

$\Delta H_M = \int_{298}^{280} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2 \, dT$

= -23.96 kJ/kg

Stream 9:

Lactose

$\Delta H_L = \int_{298}^{280} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= -1.28 kJ/kg

Protein

$\Delta H_P = \int_{298}^{280} 2.0082 \times 10^3 + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2 \, dT$

= -40.46 kJ/kg

Fat

$\Delta H_F = \int_{298}^{280} 1.9842 \times 10^3 + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2 \, dT$

= -36.16 kJ/kg

Water

$\Delta H_W = \int_{298}^{280} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3 \, dT$

= -0.6046 kJ/mol

= -3.36× 10^{-5} kJ/kg

Mineral

$\Delta H_M = \int_{298}^{280} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2 \, dT$

= -23.96 kJ/kg

Protein = $H_{9p}F_{9p} + H_{10p}F_{10p} - H_{8p}F_{8p}$

= -5355.85 kJ/h

Fat = $H_{9F}F_{9F} + H_{8F}F_{8F} - H_{7F}F_{7F}$

= -72425.91 kJ/h

Lactose = $H_{9L}F_{9L} + H_{8L}F_{8L} - H_{7L}F_{7L}$

= -49.65 kJ/h

Water = $H_{9W}F_{9W} + H_{8W}F_{8W} - H_{7W}F_{7W}$

= -0.091 kJ/h

Mineral = $H_{9M}F_{9M} + H_{8M}F_{8M} - H_{7M}F_{7M}$

= -1897.9 kJ/h

Total = $H_p + H_F + H_L + H_W + H_M$

= -79729.2 kJ/h (exothermic, since it is negative)

4.2.6 Energy Balance at Mixer (M-101)

Figure 5.7 shows water (stream 11) and butter granules (stream 9) fed into mixer and formed butter (stream 12) as the final product.

F_9 = 4826.54 kg/h

F_{9W} = 627.46 kg/h

F_{9F} = 3887.25 kg/h

F_{9P} = 103.66 kg/h

F_{9L} = 103.66 kg/h

F_{9M} = 104.51 kg/h

F_{11} = 356.46 kg/h

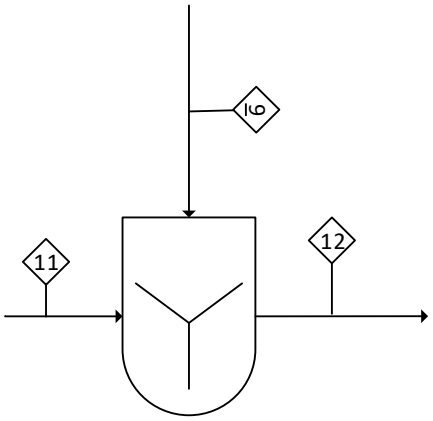
F_{11W} = 142.58 kg/h

F_{11F} = 0 kg/h

F_{11P} = 0 kg/h

F_{11L} = 0 kg/h

F_{11M} = 213.88 kg/h



F_{12} = 5183 kg/h

F_{12W} = 770.04 kg/h

F_{12F} = 3887.25 kg/h

F_{12P} = 103.66 kg/h

F_{12L} = 103.66 kg/h

F_{12M} = 318.39 kg/h

Feed Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\ dT$

Temperature is from T_1= 298K to T_2= 280K

Stream 9:

Lactose

$\Delta H_L = \int_{298}^{280} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= -1.28 kJ/kg

Protein

$\Delta H_P = \int_{298}^{280} 2.0082 \times 10^3 + (1.2089)\,T + (-1.3129 \times 10^{-3})\,T^2\,dT$

$= -40.46$ kJ/kg

Fat

$\Delta H_F = \int_{298}^{280} 1.9842 \times 10^3 + (1.4733)\,T + (-4.8008 \times 10^{-3})T^2\,dT$

$= -36.16$ kJ/kg

Water

$\Delta H_W = \int_{298}^{280} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\,dT$

$= -0.6046$ kJ/mol

$= -3.36 \times 10^{-5}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{280} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

$= -23.96$ kJ/kg

Stream 11:

Water

$\Delta H_W = \int_{298}^{301} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\,dT$

$= 0.100997$ kJ/mol

$= 5.61 \times 10^{-6}$ kJ/kg

Mineral

$\Delta H_M = \int_{298}^{301} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2\,dT$

$= 3.99$ kJ/kg

Product Enthalpy, $\Delta H = \int_{T1}^{T2} Cp\ dT$

Temperature is from T_1=298 K to T_2= 301 K

Stream 12:

Lactose

$\Delta H_L = \int_{298}^{301} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T_2$

= 0.165kJ/kg

Protein

$\Delta H_P = \int_{298}^{301} 2.0082 \times 10^{3} + (1.2089)\ T + (-1.3129 \times 10^{-3})\ T^2\ dT$

= 6.76 kJ/kg

Fat

$\Delta H_F = \int_{298}^{301} 1.9842 \times 10^{3} + (1.4733)\ T + (-4.8008 \times 10^{-3})T^2\ dT$

= 5.98 kJ/kg

Water

$\Delta H_W = \int_{298}^{301} 32.24 + (0.1923 \times 10^{-3})T + (1.055 \times 10^{-5})T^2 + (-3.595 \times 10^{-9})T^3\ dT$

= 0.100997 kJ/mol

= 5.61×10^{-6} kJ/kg

Mineral

$\Delta H_M = \int_{298}^{301} 1.0926 \times 10^{3} + 1.8896T + (-3.6817 \times 10^{-3})T^2\ dT$

= 3.99 kJ/kg

Protein = $H_{12p}F_{12p} - H_{9p}F_{9p}$

= 230318.9 kJ/h

Fat = $H_{12F}F_{12F} - H_{9F}F_{9F}$

= 163808.72 kJ/h

Lactose = $H_{12L}F_{12L} - H_{9L}F_{9L}$

= 149.781 kJ/h

Water = $H_{12W}F_{12W}$ -$H_{11W}F_{11W} - H_{9W}F_{9W}$

= 127.06 kJ/h

Mineral = $H_{12M}F_{12M} - H_{11M}F_{11M} - H_{9p}F_{9p}$

= 20217.7 kJ/h

Total = $H_p + H_F + H_L + H_W + H_M$

= 414622.16 kJ/h (endothermic, since it is positive)

CHAPTER V

5.1 APPLICATION OF FIRST AND SECOND LAW OF THERMODYNAMICS

5.1.2 COOLER (CE-101)

In cooler, the temperature is reduced from 95℃ unitl reached 33℃ for cream to undergo ripening process. The cream is ripened to at 21°C to enable flavor development to occur. The colder the temperature during ripening, the more the flavor development relative to acid production. Cooler reacts as a device that help to lower the temperature through the exchange heat between two moving fluid streams without mixing and it usually involve no work interactions (w=0) and negligible kinetic and potential energy changes for each fluid stream. The cooling water is enter the stream 4a which temperature is 5 ℃ and exits from stream 5a and its temperature is 27℃.

F_4 = 10204.62 kg/h

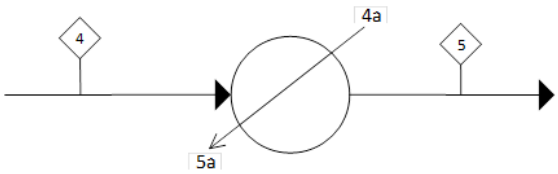
F_{4W} = 5413.95 kg/h

F_{4F} = 3994.81 kg/h

F_{4P} = 265.01 kg/h

F_{4L} = 372.56 kg/h

F_{4M} = 158.29 kg/h



F_5 = 10204.62 kg/h

F_{5W} = 5413.95 kg/h

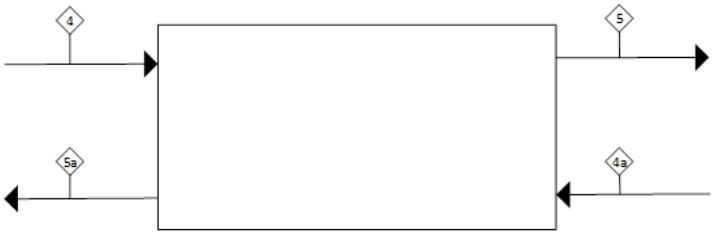
F_{5F} = 3994.81 kg/h

F_{5P} = 265.01 kg/h

F_{5L} = 372.56 kg/h

F_{5M} = 158.29 kg/h

5.2 FIRST LAW AND SECOND LAW OF THERMODYNAMICS (CE-101)



1st Law of Thermodynamics:

Mass Balance: $\sum \dot{m}_{in} = \sum \dot{m}_{out}$

$\dot{m}_4 = \dot{m}_5 = F_4 = F_5 = F_{4W} + F_{4F} + F_{4P} + F_{4L} + F_{4M} = 5413.95 + 3994.81 + 265.01 + 372.56 + 158.29 = 10204.62$ kg/h

$\dot{m}_{in(cooling\ water)} = \dot{m}_{out(cooling\ water)}$

We have the temperature of the cooling water at inlet and outlet, therefore we can calculate the mass flow rate of cooling water at both inlet and outlet.

Let us assume that:

The temperature of the cooling water at inlet = 5℃

The temperature of the cooling water at outlet = 27℃

The heat capacity is shown as below:

The heat capacity of water = 4186 J/Kg.K (“Handbook of Food Products Manufacturing: Health, Meat, Milk, Poultry)

The heat capacity of cream is 2177 J/Kg.K (“Manufacturing Yogurt and Fermented Milks)

$$\dot{q} = \dot{m} c_p \Delta T$$

$$\dot{m}_{cream} c_{p,cream} \Delta T = \dot{m} c_{p,water} \Delta T$$

$$\dot{m}_{cooling\ water} = \frac{\dot{m}_{cream}(c_{p,cream})(T_{in,cream} - T_{out,cream})}{c_{p,water}(T_{out,water} - T_{in,water})}$$

$$\dot{m} = \frac{10204.62(2177)(95-33)}{4186(27-5)}$$

$$\dot{m} = 14956.33 kg/h$$

Energy balance: $\dot{E}_{in} = \dot{E}_{out}$

$\dot{Q} = \dot{m}_4(h_5 - h_4)$

For input stream,

Stream 4:

Lactose

$\Delta H_L = \int_{298}^{368} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T^2\ dT$

= -0.531 kJ/kg

Protein

$\Delta H_P = \int_{298}^{368} 2.0082 \times 10^{3} + (1.2089)\ T + (-1.3129 \times 10^{-3})\ T^2\ dT$

= -158.52 kJ/kg

Fat

$\Delta H_F = \int_{298}^{368} 1.984 \times 10^{3} + (1.4733)\ T + (-4.8008 \times 10^{-3})T^2\ dT$

= 135.82 kJ/kg

Water

ΔH_W = The enthalpy of water is determined from the property table of water.

T= 368 K = 95 ℃, P3 =1bar =100 kPa (compressed liquid)

ΔH_W =398.09 kJ/kg

Mineral

$\Delta H_M = \int_{298}^{368} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2 \, dT$

= 91.845 kJ/kg

For output stream,

Stream 5:

Lactose

$\Delta H_L = \int_{298}^{306} 1.5488 \times 10^{-3} + 1.9625T + (-5.9399 \times 10^{-3})T^2 \, dT$

= 0.41 kJ/kg

Protein

$\Delta H_P = \int_{298}^{306} 2.0082 \times 10^3 + (1.2089)\, T + (-1.3129 \times 10^{-3})\, T^2 \, dT$

= 18.03 kJ/kg

Fat

$\Delta H_F = \int_{298}^{306} 1.984 \times 10^3 + (1.4733)\, T + (-4.8008 \times 10^{-3})T^2 \, dT$

= 15.93 kJ/kg

Water

ΔH_W = The enthalpy of water is determined from the property table of water.

T= 300 K = 33 ℃, P3 =1 bar =100 kPa (compressed liquid)

T(℃)	30	33	35
h(kJ/Kg)	125.74	ΔH_W	146.64

$\Delta H_W = 125.74 + \frac{(33-30)}{(35-30)}(146.64-125.74)$

=138.28 kJ/kg

Mineral

$\Delta H_M = \int_{298}^{306} 1.0926 \times 10^3 + 1.8896T + (-3.6817 \times 10^{-3})T^2 \, dT$

= 10.62 kJ/kg

=598965.46 kJ/h

Calculation of cooling water

Water at inlet at (stream 4a),

ΔH_W = The enthalpy of water is determined from the property table of water.

T= 278 K = 5℃, P=1bar =100 kPa (compressed liquid)

ΔH_W =21.020kJ/Kg

water at outlet at (stream 5a),

ΔH_W = The enthalpy of water is determined from the property table of water.

T= 300 K = 27℃, P=1bar =100 kPa (compressed liquid)

T(℃)	25	27	30
H(kJ/Kg)	104.83	ΔH_W	125.74

$\Delta H_W = 104.83 + \frac{(27-25)}{(30-25)}(125.74 - 104.83)$

=113.194

$\dot{Q}in = \dot{m}\ (h_5 - h_4) - \dot{m}_{cooling\ water}(h_{in,water} - h_{out,water})$

= 372.56 (0.41-(-0.531)) +265.01 (18.03-158.52) +3994.81 (15.93-135.83) + 5413.95 (138.28-398.09)+ 158.29 (10.62-91.845)-14956.33 (113.194 -21.020)

$\dot{Q}in$= -3313898.61 kg/h

2nd Law of Thermodynamics:

Entropy change: $d\dot{S} = \frac{d\dot{Q}}{T}$

Entropy balance: $(S_{in}-S_{out}) + S_{gen} = \Delta S_{system}$

For steady-flow processes, $\Delta\dot{S}_{system}=0$

$\dot{S}_{gen}=\sum\dot{m}_e\dot{s}_e - \sum\dot{m}_i\dot{s}_i - \sum\frac{\dot{Q}_k}{T_k}$

$\dot{m}_i = \dot{m}_e = 10204.62$ kg/h

$\Delta s_{Li} = \int_{T_1}^{T_2} \frac{C_p T}{T}$

$= \int_{298}^{368} 1.5488 \times 10^{-3}T^{-1} + 1.9625 + (-5.9399\times 10^{-3})T\, dT$

= -1.084 kJ/kg·K

$\Delta s_{Pi} = \int_{298}^{368} 2.0082 \times 10^{3}T^{-1} + (1.2089) + (-1.3129\times 10^{-3})\ T\, dT$

= -178.56kJ/kg·K

$\Delta s_{Fi} = \int_{298}^{368} 1.984 \times 10^{3}T^{-1} + (1.4733) + (-4.8008 \times 10^{-3})T\, dT$

= 409.83 kJ/kg·K

The entropy of water is determined from the property table of water.

T= 368 K = 95 ℃, P= 1 bar = 100 kPa (compressed liquid)

Δs_{Wi} =1.2504 kJ/kg.K

$\Delta s_{Mi} = \int_{298}^{368}(1.0926 \times 10^{3})T^{-1} + 1.8896 + (-3.6817 \times 10^{-3})T\, dT$

=276.98 kJ/kg·K

Output stream 5:

$\Delta s_{Lo} = \int_{298}^{306} 1.5488 \times 10^{-3}T^{-1} + 1.9625 + (-5.9399 \times 10^{-3})T\, dT$

$= 1.35$ kJ/kg·K

$\Delta s_{Po} = \int_{298}^{306} 2.0082 \times 10^{3}T^{-1} + (1.2089) + (-1.3129 \times 10^{-3})\ T\, dT$

$= -596.6$ kJ/kg·K

$\Delta s_{Fo} = \int_{298}^{306} 1.984 \times 10^{3}T^{-1} + (1.4733) + (-4.8008 \times 10^{-3})T\, dT$

$= 52.75$ kJ/kg·K

The entropy of water is determined from the property table of water.

T=306 K =33 ℃, P= 1 bar = 100 kPa (compressed liquid)

T(℃)	30	33	35
s(kJ/kg.K)	0.4368	Δs_{Wo}	0.5051

$\Delta s_{Wo} = 0.4368 + \frac{(33-30)}{(35-30)}(0.5051-0.4368)$

$= 0.47778$kJ/kg.K

$\Delta s_{Mo} = \int_{298}^{306} 1.0926 \times 10^{3}T^{-1} + 1.8896 + (-3.6817 \times 10^{-3})T\, dT$

$= 35.17$ kJ/kg·K

At inlet of cooling water (stream 4a),

The entropy of water is determined from the property table of water.

T=278 K =5 ℃, P= 1 bar = 100 kPa (compressed liquid)

Δs_{Wi} =0.0763 kJ/kg.K

At the outlet of cooling water (stream 5a),

The entropy of water is determined from the property table of water.

T=300 K =27 ℃, P= 1 bar = 100 kPa (compressed liquid)

T(℃)	25	27	30
s(kJ/kg.K)	0.3672	Δs_{Wo}	0.4368

Δs_{Wo} =0.3672+$\frac{(27-25)}{(30-25)}$(0.4368-0.3672)

=0.39504 kJ/kg·K

$\Sigma \dot{m}_o \dot{s}_{o(total)}$ = 372.56 kg/h (1.35 kJ/kg·K) + 265.01 kg/h (-596.6 kJ/kg·K) + 3994.81 kg/h

(52.75 kJ/kg·K) + 5413.95 kg/h (0.47778 kJ/kg·K) + 158.29 kg/h (35.17kJ/kg·K) +0.39504 kJ/kg·K (14956.33 Kg/h)

= 67186.3 kJ/h·K

$\Sigma \dot{m}_i \dot{s}_{i(total)}$ = 372.56 kg/h (-1.084 kJ/kg·K) + 265.01 kg/h (-178.56 kJ/kg·K) + 3994.81 kg/h (409.83 kJ/kg·K) + 5413.95 kg/h (1.2504 kJ/kg·K) + 158.29 kg/h (276.98/kg·K) +14956.33Kg/h (0.0763 kJ/Kg.K)

=1641222.876 kJ/h.K

$\dot{Q}in$= -3313898.61 kg/h T_{in} = 298K

$\dot{S}_{gen} = \sum \dot{m}_o \dot{s}_o - \sum \dot{m}_i \dot{s}_i - \sum \frac{\dot{Q}_k}{T_k}$

$= (67186.3\text{-}1641222.876) \quad - \frac{-3313898.61}{298}$

$= -1562916.11 \text{ kJ/K·hr} \div 3600$

$= -434.14 \text{ kW/K}$

$\dot{S}_{gen}$ for this heat exchanger is negative. The negative entropy generation indicates the impossible process for cooler. However, this is not true and it means that the cooler is not a steady-flow process which is not in scope of study.

CHAPTER VI

MATERIAL ENGINEERING

5.1 TYPE OF MATERIAL

In the manufacturing butter, the conditions required in the production of butter are at a pressure of 6 bar and temperature of 95 ºC. The reaction occurring in the pasteurizer in exothermic process whereby heat is released. Therefore, the material chosen for this process to occur must be able to withstand the high pressure and high temperature in the process. The material chosen to be used for our unit operation must meet all the criteria in order to ensure that all unit operations can last long keeping the system in operation without much need for maintenance.

Table 6.1 Characteristics of Stainless Steel A-286

Characteristics	Description
Tensile strength	1035MPa
Young's modulus	201 GPa
Ductility	High
Yield strength	759MPa
Corrosion resistance	Excellent corrosion resistance
Fire and heat resistance	Resist scaling and retain strength at high temperatures
Melting point	1399 ºC
Major Composition	53% Fe, 25% Ni, 15% Cr, 7% Ti
Price	The price of stainless steel is US $2000-3000/ Ton

("A286 stainless steel suppliers, Alloy A286 price, ASTM A286 grade 660" n.d.)

The table below show the characteristics for stainless steel A-36.

Table 6.2 Characteristics of A-36

Characteristics	Description
Tensile strength	36300 psi
Young's modulus	29 x 10^6 psi

Ductility	Moderately high
Corrosion resistance	Low corrosion resistance
Fire and heat resistance	Strength, rigidity and tensile strength degrade at high temperature
Melting point	1370 °C
Major Composition	98% Fe, 0.25% C, 0.2% Cu, 1.03% Mn
Price	The price of stainless steel is US $300-600/tonne

(Source: AZoM 2012)

The properties of stainless steel A-286 have made it appropriate for items that need high tensile strength, oxidation resistance, and corrosion resistance. Stainless steel A-286 have high strength and corrosion resistance which makes it ables to withstand the temperature as high as 1300-degrees Fahrenheit and oxidation resistance of up to 1800-degrees Fahrenheit.It can last longer compared to other conventional metals although the price is rather expensive.

The table below show that the reasons for choosing the material for each unit operation.

Table 6.3 Material Chosen for Unit Operators

Unit Operation	Types of Material Selected	Reason
Pasteurizer	A-286	A-286 Stainless steel does not rust easily. Longer lasting and can withstand high temperature since the temperature in pasteurizer is higher compared to others.
Mixer	A-36 steel	High strength and toughness. withstand high pressure and temperature. Low cost.
Centrifugal separator	A-283	Withstand high pressure. Good resistance to corrosion.
pump	Brass	Can repel bacteria naturally. Good resistance to abrasion corrosion. Easy to maintain.
churner	A-36 steel	High strength and toughness.

6.2 CORROSION CONTROL AND PREVENTION

Metal corrosion occurs as result of chemical reactions between it and surrounding environment when metal is exposed to moisture and other elements or chemicals. All metals can corrode which can decrease the efficiency of the unit operator. There are some useful methods to prevent corrosion of metals.

Table 6.4 Ways to prevent corrosion

1.Use non-corrosive metals such as stainless steel as material for unit operators.
2.Carbon fiber coating to prevent the corrosion of metals and also strengthens the metal.
3.Corrosion inhibitors react with the surface of the metal or the surrounding gases to suppress the electrochemical reactions leading to corrosion.
4. use drying agents and moisture barrier products.
5. Design modifications can help reduce corrosion.

("Methods, Tips & Solutions To Stop & Prevent the Corrosion of Metals" n.d.)

6.3 CALCULATION OF THE CORROSION RATE OF THE PASTEURIZER

The weight loss of the reaction in any chemical plant is usually related with corrosion rate. Corrosion rate is used to calculate how much the pasteurizer corrodes for a certain exposure time. The corrosion rate (a.k.a Corrosion Penetration Rate) of a pasteurizer can be calculated by using the formula below:

$$\text{CPR} = \frac{KW}{\rho A t}$$

Where W is the weight loss of the pasteurizer during the exposure time, ρ is the density of the material, t is the time of the exposure, A is the exposed specimen area and K is a constant which has a value of 87.6. Hence, the weight loss of the pasteurizer can be calculated by using this formula. The density of the steel is 7916 kg/m^2 and the CPR of the steel is 0.00254 mm/yr. We assume the pasteurizer to be cylindrical in shape. The radius of the pasteurizer is 3.0 m and the height of the pasteurizer is 30m. We take the time of exposure as 15 years.

The surface area of the pasteurizer $= 2\pi rh + 2\pi r^2$

$= 2\pi(3.0)(30) + 2\pi(3.0)^2$

$= 622.04$ m^2

$= 6220400$ cm^2

The amount of the weight loss of the pasteurizer is as below:

$$W = \frac{(CPR)(\rho At)}{K}$$

$$= \frac{(0.00254\ mm/yr)(7.916\ \frac{g}{cm^3})(6220400\ cm^2)(15\ yrs)}{87.6}$$

= 21416.33 mg

= 0.021416 kg

CHAPTER VII

CONCLUSION

The objectives of this study in chapter 1 and 2 is to introduce the process and for us to learn about the chemical and physical properties of butter. The production of butter including separation, ripening, aging, churning, draining and washing, working and packaging and storage process.

In addition, we learnt the way to measure and calculate the values of material balance and energy balance in the production of butter. Besides, this study also helps us to draw process flow diagram (PFD) in a systematic way which help us a lot on how to determine the material balance and energy balance more effectively.

In chapter 3, we learnt the waste product that will be produced by the production of butter and the ways to overcome these issues. In this process, the plant is designed to produce 43.54kilotonne butter per year. The plant design assumes that the days of operation for the design is 360 days per year which is equal to 8400 hours per year.

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APPENDIX

CALCULATION FOR MATERIAL BALANCE

4.1.1 CENTRIFUGAL SEPARATOR (CS-101)

$F_1 = F_3 + F_{13}$ $F_1 = F_{13} + 13307.43$

$0.87F_1 = 0.90\ F_{13} + 0.64F_3$

$0.87(F_{13} + 13307.43) = 0.90\ F_{13} + 0.64(13307.43)$

$0.87F_{13} + 11577.46 = 0.90\ F_{13} + 8516.76$

$-0.03F_{13} = -3079.34$

$F_{13} = 102644.67$

$F_1 = 102644.67 + 13307.43 = 115952.1$

4.1.2 PASTEURIZER (P-101)

$F_3 = F_{14} + F_4$ $F_3 = F_{14} + 10204.62$

$0.64F_3 = F_{14} + 0.53(10204.62)$

$0.64(F_{14} + 10204.62) = F_{14} + 5413.95$

$0.64F_{11} + 6530.96 = F_{14} + 5413.95$

$-0.36F_{14} = -1117.01$

$F_{14} = 3102.81$

$F_3 = 310281 + 10204.62=13307.43$

4.1.3 CHURNER (C-101)

$F_7 = F_8 + F_{10}$

$F_7 = F_8 + 4826.59$

$H_2O = 0.53F_7 = 0.89F_8 + 0.13F_9$

$0.53(F_8 + 4826.54) = 0.89F_8 + 621.96$

$0.53F_8 + 2558.07 = 0.89F_8 + 621.96$

$-0.36F_8 = 5378.08$

$F_7 = 5378.08 + 4826.54=10204.62$

4.1.4 MIXER (M-101)

$F_9 + F_{11} = F_{12}$ $F_9 = 5183 – F_{11}$

$F_9 + F_{11} = 5183$

$0.13F_9 + 0.4F_{11} = 0.15(5183)$

$0.13(5183 – F_{11}) + 0.4F_{11} = 770.04$

$673.79 – 0.13F_{11} + 0.4F_{11} = 770.04$

$0.37F_{11} = 96.25$

$F_{11} = 356.40$ $F_9 = 4826.54$

Cream Flavor MSDS

MATERIAL SAFETY DATA SHEET

McKnight Standard LLC
Flavorah
PO Box 2624
Woodinville, WA

Information: 1 (844) 358-8273

Emergency : For Dangerous Goods Incident Spill, Leak, Fire, Exposure, or Accident, Call CHEMTREC Day or Night Within USA and Canada: 1-800-424-9300

SECTION 1: IDENTIFICATION

Product ID: FLV 100150 **Product Name:** Flavorah Cream Flavor

Recommended Use: Not for personal use in this form. Flavoring intended for further processing in the E-Cigarette Industry.

SECTION 2: COMPOSITION

A Flavoring Compound: A multi component mixture of flavoring ingredients. The specific chemical identities of the ingredients not listed herein are considered by Flavorah to be trade secrets and are withheld in accordance with the provisions of 1910.1200 of Title 29 of the US Code of Federal Regulations.

WARNING: This flavor contains ETHYL ALCOHOL (CAS# 64-17-5).

SECTION 3: HAZARD IDENTIFICATION & EMERGENCY OVERVIEW

Overview: When vaporized poses irritation to the eyes, nose, and respiratory tract. Excessive inhalation may cause lung damage.
Combustible: Avoid open flames, excessive heat, or other sources of ignition.
Eye: May cause eye irritation. May cause redness and pain.
Skin: May cause moderate skin irritation, irritation, or pain. May be harmful if absorbed through skin.
Ingestion: Harmful if swallowed; nausea, vomiting and diarrhea may occur.
Inhalation: Causes respiratory tract irritation.

SECTION 4: FIRST AID MEASURES

Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention.
Skin: Immediately flush skin with plenty of water for at least 15 minutes, remove any contaminated clothing and shoes. Get medical attention.
Ingestion: If victim is conscious and alert, give 2-4 cupfuls of milk or water. Never give anything by mouth to an unconscious person. Seek medical attention.
Inhalation: Causes respiratory tract irritation

SECTION 5: FIRE FIGHTING MEASURES

Flash Point:	164˚F
Extinguishing Media:	Carbon Dioxide; Foam
Special Fire Fighting Procedures:	Wear approved NIOSH self-contained breathing apparatus and full protective clothing when fighting fires involving chemicals.
Unusual Fire & Explosion Hazard:	Closed containers may build up pressure at elevated temperatures. If possible containers should be cooled with a water spray.

SECTION 6: ACCIDENTAL RELEASE MEASURES

Accidental Release:	Use absorbed material to pick up spills, place in an approved container. Consult section 8 of this MSDS for PPE requirements.
Waste Disposal:	Observe Federal, State, and Local laws concerning health and pollution.

SECTION 7: HANDLING & STORAGE

Handling:	Wash thoroughly after handling. Wash hands before eating. Use only in a well ventilated area. Avoid breathing dust, vapor, mist, or gas. Do not get on skin or in eyes. Avoid ingestion and inhalation.
Storage:	Keep away from sources of ignition. Store in a cool, dry place. Store in a tightly closed container.

SECTION 8: EXPOSURE CONTROLS & PERSONAL PROTECTION

Respiratory:	Use an NIOSH approved respirator with organic vapor cartridges.
Eye:	May cause eye irritation. May cause redness and pain.
Skin:	Wear appropriate chemical resistant protective gloves to prevent skin exposure. Wear aprons to reduce skin exposure, change clothing should it become saturated.
Engineering Controls:	Facilities should be equipped with eye wash stations and safety shower. Use process enclosure or local exhaust ventilation, or other engineering controls to help control airborne levels. Use closed systems to transfer flavorings whenever possible.
Worker Health:	NIOSH recommends regularly scheduled spirometry testing of lung function, following the latest American Thoracic Society guidelines, for all workers with potentially hazardous exposure to flavorings
NIOSH Alert:	NIOSH has published an Alert on preventing lung disease in workers who use or make flavorings. We recommend that you review this publication to obtain a thorough understanding of the methods recommended by NIOSH to reduce the risks of worker exposure to flavoring. (NIOSH Publication Number 2004-110)

SECTION 9: PHYSICAL & CHEMICAL PROPERTIES

Appearance & Physical State:	CLEAR, COLORLESS TO SLIGHT TINT, MOBILE
Boiling Point:	NA
Melting Point:	NA
Specific Gravity:	1.035 + or - .01
Vapor Pressure:	NA
Vapor Density:	NA
Solubility in H2O:	WATER SOLUBLE

SECTION 10: STABILITY AND REACTIVITY

Stability:	Stable
Conditions to Avoid:	Excessive heat, Open flames, or other sources of ignition
Materials to Avoid:	None Known
Hazardous Polymerization Products:	None Known
Hazardous Combustible or Decomposition Products:	None Known

SECTION 11: TOXICOLOGICAL INFORMATION

TLV: Not Established
PEL: Not Established
Carcinogenicity: **NTP:** NO **IARC:** NO **OSHA:** NO

SECTION 12: ECOLOGICAL INFORMATION

Flavor is expected to biodegrade to a moderate extent in the environment. It is not expected to significantly bio-accumulate.

SECTION 13: DISPOSAL CONSIDERATION

Empty all containers until no free liquid remains. Minimize release to the environment. Dispose of in accordance with Federal, State or Local regulations.

SECTION 14: TRANSPORT INFORMATION

DOT Hazard Class: Not Regulated
IATA: Not Regulated

SECTION 15: REGULATORY INFORMATION

SARA Title Ill: To the best of our knowledge this product contains no toxic chemicals subject to the supplier notification requirements of section 313 of the Superfund Amendments and Reauthorization Act (SARA/EPCRA) and the requirements of 40 CFR Part 372.

SECTION 16: OTHER INFORMATION

Material Safety Data Sheet prepared by McKnight Standard LLC

The information contained herein is believed to be accurate but is not warranted to be so. Data and calculations are based on information furnished by the manufacturer of the product and manufacturers of the components of the product. Users are advised to confirm in advance of need that information is current, applicable and suited to the circumstance of use. Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet.
Furthermore, vendor assumes no responsibility for injury caused by abnormal use of this material even if reasonable safety procedures are followed. Any questions regarding this product should be directed to the manufacturer of the product as described in Section 1.

NATURAL SOURCING
Specialists in Cosmeceutical Ingredients

341 Christian Street, Oxford, CT 06478 USA
Tel: (203) 267-6061 Fax: (203) 267-6065
www.naturalsourcing.com info@naturalsourcing.com

MATERIAL SAFETY DATA SHEET

BUTTERMILK POWDER

MSDS

1. PRODUCT NAME AND COMPANY IDENTIFICATION

Product Name:	**BUTTERMILK POWDER**
Product Use:	Personal Care Formulations
Company Name:	Natural Sourcing
Company Address:	341 Christian Street, Oxford, CT 06478, USA
Date Issued:	1/23/2012
Emergency Telephone Number:	**Chemtrec Tel: (800) 262-8200**

2. COMPOSITION/INGREDIENT INFORMATION

Ingredients:	
Buttermilk Powder	100%
Hazardous Components:	None
CAS #:	

3. HAZARDS IDENTIFICATION

Routes of Entry	
Eye Contact:	Non hazardous
Skin Contact:	May cause irritation or allergy symptoms in individuals with milk allergies.
Ingestion:	Non hazardous
Inhalation:	May cause irritation or allergy symptoms in individuals with milk allergies

4. FIRST AID MEASURES

Eyes:	Flush with plenty of water or eye wash solution for 15 Minutes. Get medical attention if irritation persists.
Skin:	Wash with soap and water.
Ingestion:	N/A
Inhalation:	Remove to fresh air. Get medical attention if allergy symptoms occur.
Medical Conditions Generally Aggravated by Exposure:	Milk allergies

5. FIRE FIGHTING MEASURES

Flash Point :	N/A
Flammable Limits	
LEL:	
UEL:	

Extinguishing Media:	Dry Chemical, carbon dioxide, Halon, water spray.
Special Firefighting Procedures:	Use of a self-contained breathing apparatus is recommended.
Unusual Fire & Explosion Hazards:	None
Hazard Thermal Decomposition Products:	N/A

6. ACCIDENTAL RELEASE MEASURES (STEPS FOR SPILLS)

Methods for Cleaning Up:	Dust should be contained. Clean spills promptly to prevent slip/fall hazard. Scoop spilled material into containers for proper disposal. Prevent entry into sewers or waterways.

7. HANDLING AND STORAGE

Handling	
Safe Handling:	N/A
Storage	
Requirements for Storage Areas and Containers:	Store in a cool, dry storage area.

8. EXPOSURE CONTROL/PERSONAL PROTECTION

Eye:	Safety glasses may be worn.
Skin/Body:	Gloves and Aprons may be worn.
Respiratory:	Use of NIOSH-approved dust mask during usage.
Work/Hygiene Practice:	Recommend mechanical ventilation
Other:	Evaluate need based on application.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Free flowing powder
Color:	Light cream
Odor:	Characteristic of Buttermilk, Slightly sweet
pH:	N/A
Vapor Pressure (mm Hg.):	N/A
Vapor Density (AIR = 1):	N/A
Boiling Point:	N/A
Melting Point:	N/A
Specific Gravity: (H20 = 1)	N/A
Evaporation Rate:	NA
Solubility in water:	Soluble
Water Reactive:	No

10. STABILITY AND REACTIVITY

Stability:	Stable under normal conditions
Incompatibility (Materials to Avoid):	None
Hazardous Decomposition or Byproducts:	None
Conditions to Avoid:	None

Incompatibility (Materials to Avoid): None
Hazardous Polymerization: Will Not Occur

11. TOXICOLOGICAL INFORMATION

Not available

12. ECOLOGICAL INFORMATION

Not available

13. DISPOSAL CONSIDERATIONS

Waste Disposal Methods: Material is not considered hazardous under federal regulations. Dispose in accordance with state and local regulations.

14. TRANSPORT INFORMATION

Not Available

15. REGULATORY INFORMATION

Not available

16. ADDITIONAL INFORMATION

This information is provided for documentation purposes only.
This product is not considered hazardous.

Disclaimer: The complete range of conditions or methods of use are beyond our control therefore we do not assume any responsibility and expressly disclaim any liability for any use of this product. Information contained herein is believed to be true and accurate; however, all statements or suggestions are made without warranty, expressed or implied, regarding accuracy of the information, the hazards connected with the use of the material or the results to be obtained from the use thereof. Compliance with all applicable federal, state, and local laws and local regulations remains the responsibility of the user.

This bulletin cannot cover all possible situations which the user may experience during processing. Each aspect of your operation should be examined to determine if, or where, additional precautions may be necessary. All health and safety information contained in this bulletin should be provided to your employees or customers

Material Safety Data Sheet

EU Regulation: 1907/2006

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product Identification

Product Name	GHEE, BUTTER ORGANIC				
Biological Definition	N/A				
INCI Name	GHEE				
Synonyms & Trade Names	ORGANIC GHEE BUTTER				
Internal Product Code	K0200				
CAS-No	NOT LISTED	**EC No.**	NOT LISTED	**EINECS No.**	NOT LISTED

1.2 Details of the supplier of the safety data sheet

Company Address	O&3 Unit 2, Athelstan Business Park, Hanwell Lane, Hutton Conyers, Ripon, HG4 5BF, England.
Email	ThomasKerfoot@Oand3.com

1.3 Details of the supplier of the safety data sheet

Emergency Contacts	Mrs. Eleanor Wade (07968 200167)

SECTION 2: Hazards Identification

2.1 Classification of the substance or mixture	
Classification (67/548/EEC)	This product is not dangerous according to REACH Regulation 1907/2006.
Classification (EU1272/2008)	This product does not belong to any list of substances supposedly hazardous to human or animal health according to EU Regulation 1272/2008 & any further amendments, nor to those having recognized exposition limits. Care should be taken when handling hot oil as it may constitute a burn hazard. Spills can constitute a slippage hazard.
2.2 Label Elements	Label in accordance with Regulation (EC) No 1272/2008.
GHS Label	None.
Signal Word	None.
Contains	None.
Hazards Statement	None.
Signal Word	None.
Precautionary Statements	None.
Supplementary Precautionary Statements	None.
Section 16 (Other Information): Risk & Safety phrases in full.	
2.3 Other Hazards	
Adverse physio-chemical properties	None.
Adverse effects on human health	None.

SECTION 3: Composition of Ingredients

3.1 Substances	Not Applicable.
3.2 Mixtures	Not Applicable.

SECTION 4: First Aid Measures

4.1 Description of First Aid Measures	
General Information	Always remove contaminated clothing immediately.
Inhalation	Not expected for this particular product, however always best avoiding proactive inhalation.

Ingestion	No instruction as this is a non-toxic product.
Skin Contact	No instruction as this is a non-toxic product.
Eye Contact	Wash immediately & thoroughly with clean tap water.
4.2 **Most important symptoms & effects (Acute & Delayed)**	None.
4.3 **Indication of any immediate medical attention or special treatment required**	Not Applicable.

SECTION 5: Fire Fighting Measures

5.1 **Extinguishing material**	Foam, Co2, Dry Chemical Powder.
5.2 **Special hazards arising from the substance Or mixture**	This product may only form ignitable mixtures or burn above the flash point. Dangerous combustion products include smoke & oxides of carbon.
5.3 **Advice for fire-fighters**	Standard. Wear self-contained breathing apparatus in confined spaces.

SECTION 6: Accidental Release Measures

6.1 **Personal precautions**	None Required.
6.2 **Environmental precautions**	None Required.
6.3 **Methods & material for containment and cleaning up**	Spills can be absorbed by cloth or sawdust, washed away with water & cleaned with sodic products.
6.4 **References to other sections**	Refer & consider section 8. Refer & consider section 13.

SECTION 7: Handling & Storage

7.1 **Precautions for safe-handling**	Handle in accordance with good hygiene and safety practice. Keep containers sealed when not in use. Prevent spills & leaks to avoid slip hazard. Always wear personal protective clothing (refer to section 8). Do not eat, drink, sniff or smoke whilst handling this product. Provide suitable mechanical equipment for the safe handling of drums & heavy packages.
7.2 **Conditions for safe storage, including any incompatibilities**	Keep the product container tightly closed, in a dry, ventilated area (at temperatures <20°C). Keep away from potential sources of ignition and protected from light. Maintain limited contact with oxygen.
7.3 **Specific end use(s)**	No Data.

SECTION 8: Exposure Controls & Personal Protection

8.1 **Control Parameters**	None.
8.2 **Exposure Controls**	
Eye Protection	Not required as a non-toxic product, however we still recommend taking precautions by wearing protective eye-wear when handling the product.
Hand Protection	None.
Respiratory Equipment	None.
Hygiene Measures	None.
Engineering Measures	None.

SECTION 9: Physical & Chemical Properties	
9.1 Physical & Chemical Properties	
Appearance	SOFT BUTTER (OIL AT ROOM TEMPERATURE)
Colour	YELLOW
Odour	SWEET & NUTTY
Relative Density	NO DATA
Flash Point (°C)	>280°C.
Refractive Index	NO DATA
Melting Point (°C)	27.0 – 40.0
Boiling Point (°C)	>100°C.
Vapour Pressure	NO DATA.
Solubility in Water @ 20°C	INSOLUBLE.
9.2 Other Information	NO DATA.
SECTION 10: Stability & Reactivity	
10.1 Reactivity	Not Applicable.
10.2 Chemical stability	Stable under suggested storage conditions (<20°C).
10.3 Possibility of hazardous reactions	No.
10.4 Conditions to avoid	Storage at high temperatures. Do not store above 20°C.
10.5 Incompatible materials	Concentrated acids, alkalis & oxidising agents.
10.6 Hazardous decomposition products	This product does not decompose under normal conditions. Under fire conditions the product will produce a mixture of irritating fumes & smoke.

SECTION 11: Toxicological Information	
11.1 Toxicological effects	
Acute Toxicity	A non-toxic product. For pharmaceutical & cosmetic use only. This product does not carry a microbiological specification as it is sterilised in the refining process. It does not contain any impurities. This product is not included in the list of substances prohibited in cosmetic products or subject to restrictions. It does not contain colorants, preservatives or UV filters (Annex II – VI of EU regulation 1223/2009).
Skin irritation	Not Applicable.
Eye damage or irritation	Not Applicable.
Respiratory or skin sensitivity	Not Applicable.
Germ cell mutagenicity	Not Applicable.
Carcinogenicity	Not Applicable.
Reproductive toxicity	Not Applicable.

STOT – single exposure	Not Applicable.
STOT – repeated exposure	Not Applicable.
Aspiration hazard	Not Applicable.
Other information	Not Applicable.

SECTION 12: Ecological Information

12.1 **Toxicity**	Low - None.
12.2 **Persistence & degradability**	>90% (OECD)
12.3 **Bio- accumulative potential**	None.
12.4 **Mobility in soil**	Low – None.
12.5 **Results of PBT & VPVB assessment**	Not Available.
12.6 **Other adverse effects**	None.

SECTION 13: Disposal Information

13.1 **Waste treatment methods**	Always recover spilled product. Discard waste material with authorized waste management services. Act in accordance with local & national waste regulations.

SECTION 14: Transport Information

14.1 **Transport Information**	
Warning icon	Road (ADR), Rail (RID), Sea (IMDG) and Air (ICAO), transport not restricted in drums or food tankers.
Shipping Name	Not Applicable.
UN Number (Road)	Not Applicable.
ADR Class	Not Applicable.
Hazard Number (ADR)	Not Applicable.
Hazchem Code	Not Applicable.
UN Number (Sea)	Not Applicable.
IMDG Class	Not Applicable.
IMDG Pack GR.	Not Applicable.
EMS	Not Applicable.
UN Number (Air)	Not Applicable.
Air Class	Not Applicable.
Air Pack GR.	Not Applicable.

SECTION 15: Regulatory Information

15.1	

Product specific safety, health & environmental regulations & legislation	
EU Directives	Regulation (EC) No 1907/2006 of the European Parliament and of the council of 18th December 2006. Concerning the registration, evaluation, authorization & restriction of chemicals (REACH), establishing a European Chemicals Agency, amending Directive 199/45/EC and repealing council regulation (EEC) No793/93 & commission regulation (EC) No1488/94 as well as council directive 76/769/EEC & commission directive 91/155/ECC, 93/67/ECC, 93/105/EEC & 2000/21/EC (including amendments).
Statutory Instruments	The Chemicals (Hazard Information & Packaging for Supply Regulations 2009 (S.I.2009 No 716).
Approved Code of Practice	Classification & labelling of substances & preparations dangerous for supply. Safety data sheets for substances & preparations.
Guidance Notes	Workplace exposure limits EH40. CHIP for everyone HSG 108.
15.2 Chemical Safety Assessment	Assessment has not been carried out as this is a non-hazardous material according to article 31 of REACH 1907/2006.

SECTION 16: Other Information

Allergens:	None.
Training Instructions: Refer to possible hazard before use of this product.	
Abbreviations & Acronyms:	
MSDS	Material Safety Data Sheet.
INCI	International Nomenclature of Cosmetic Ingredients.
CAS	Chemical Abstract Service.
IMDG	International Maritime code for Dangerous Goods.
ADR	Accord European sur le transport des merchandises Dangereuses par Route (European Agreement concerning the international Carriage of Dangerous goods by Road).
RID	International Carriage of Dangerous Goods by Rail.
ICAO	International Civil Aviation Organization.
ADN	International Carriage of Dangerous Goods by Inland Waterways.
GHS	Globally Harmonized System of classification & labelling of chemicals.
Trem Card	Transport Emergency Card.
STOT	Specific Target Organ Toxicity.

Documentation Revision	
Date	**Change Description**
10th April 2018	Data Launch

INTERNATIONAL INGREDIENT CORPORATION

150 Larkin Williams Industrial Ct • P.O. Box 26377
St. Louis, Missouri 63026 •636-343-4111

Safety Data Sheet	
Product Group-Milk	
Issue 1	05-11-2016

Safety Data Sheet

Section 1: Identification

Feed Ingredient Product Group: Milk Included Product Names: Soluble Milk Product, Nutri-Gold, Calf Milk Ingredient, Nutri-Source
Intended Use: Feed and Other
Manufacturer: Various International Ingredient Corporation Locations
Emergency Health and Safety Number: (636) 343-4111
SDS Information: WWW.IICAG.COM

Section 2: Hazard(s) Identification

Classification: Organic Dust
Label Elements: N/A due to FDA Labeling Exemption
Hazard Statement(s): Class 2B eye irritant. May cause breathing difficulties if inhaled. May create a flash fire or explosion hazard if dust of certain particle size is suspended in air at sufficient concentration in a confined space and exposed to an ignition source.
Precautionary statement: May be mechanical eye irritant. Rinse eyes with water for several minutes. Avoid breathing dust. Excessive inhalation may affect nose, throat, and lungs. Ingredient dust may burn if suspended in air and may create a flash fire/explosion hazard. Avoid ignition sources.
Emergency Overview: May be mechanical irritant to eyes. Excessive inhalation of ingredient dust may affect nose, throat and lungs. May form combustible dust concentration in air (see "Explosion Hazard" below).
Explosion Hazard: Ingredient is generally considered not hazardous, but dust generated through downstream activities that may reduce it particle size (E.G., shipping, handling, transferring to bins, etc.) may create a hazardous condition. If exposed to an ignition source, ingredient dust may burn. Airborne dust in sufficient concentrations when exposed to an ignition source may flash.

Section 3: Composition/Information on Ingredients

Component, CASRN, Concentration: Dust from prepared feed ingredient-100%.

Section 4: First-Aid Measures

Inhalation: Remove person from exposure. Seek medical attention for any breathing difficulty.
Ingestion: If swallowed, give several glasses of water to dilute. Never give anything by mouth to an unconscious person.
Skin Contact: Wash affected skin with soap and water.
Eye Contact: Flush eyes with water. Seek medical attention as needed.

Section 5: Fire Fighting Measures

Hazardous combustion products: Oxides of carbon.
Special firefighting procedures: Extinguish with water fog, dry chemical powders or foam. Do not use strong streams of water or dry chemical if dust can be dispersed into the air. Dust placed in suspension with an ignition source may flash.
Unusual fire and explosion hazards: Explosion hazard may exist for combustible dusts of certain particle size and moisture content when suspended in air at certain concentrations and subjected to an ignition source.

Section 6: Accidental Release Measures

Clean up with soft bristle broom(s) or vacuum approved for a class II hazardous location. Dust deposits should be maintained to a minimum on surfaces, as these could form an explosive mixture if they are released into the atmosphere in sufficient concentration. Avoid dispersal of dust in the air (I.E., cleaning dust surfaces with compressed air in the presence of an ignition source should not be allowed). Non-sparking tools should be used.

Section 7: Handling and Storage

Avoid dispensing dust in air and exposure to potential ignition sources. Remove ingredient dust from area/processing equipment prior to using any heat producing equipment, such as arc welders, cutting torches, and spark/heat producing tools such as portable surface grinders. According to 29 CFR 1910.272(F), a hot work permit is required.

Section 8: Exposure Controls/Personal Protection

Respiratory protection: May cause irritation of the nasal membranes or the upper respiratory tract if dust exceeds the nuisance level. Wear an approved NIOSH dust respirator whenever dust concentrations in the work area are above ACGIH TLV/OSHA PELS. Nuisance Dust-PNOR.
Total Dust: 15 MG/Cu M Respirable Fraction: 5 MG/Cu M
Ventilation: Local exhaust if needed.
Mechanical (general): If needed. Insure that dust handling systems (such as exhaust ducts, dust collectors, vessels, and processing equipment) are designed in a manner to prevent the escape of dust into the work areas. Use only appropriately classified electrical equipment and powered industrial trucks.
Protective gloves: N/A
Eye protection: Safety glasses/goggles suggested in dusty conditions.
Work/Hygienic Practices: Good personal hygiene practices should be followed. Wash hands and face before eating, drinking, etc.
General: Avoid dust accumulation and control ignition sources. Where appropriate, employ grounding, venting, and explosion relief provisions in accordance with accepted engineering practices in processes capable of generating dust and/or static electricity. Avoid accumulation of dust on surfaces to prevent secondary dust explosions. Refer to appropriate OSHA, NFPA, and applicable standards.

Section 9: Physical and Chemical Properties

Flash point (method): N/A
Flammable limits: LEL: Variable, UEL: Unknown
Auto ignition temperature: Unknown
Appearance: Cream to light tan color with a sweet smell.
Solids contents: +-95%

Section 10: Stability and Reactivity

Stability: Unstable: Stable: X, Condition to avoid: N/A
Incompatibility (materials to avoid): None known
Hazardous decomposition or byproducts: None known
Hazardous Polymerization: May occur: Will not occur: X, Conditions to avoid: N/A

Section 11: Toxicological Information

Routes of entry: Inhalation: X, Skin: X, Eyes: X, Ingestion: Unlikely
Carcinogenicity: NTP: No, Arc Monographs: No, OSHA regulated: No
Acute: May be mechanical irritant to skin and eyes. Excessive inhalation of ingredient dust may affect nose, throat and lungs.
Chronic: Repeated and prolonged inhalation of ingredient dust may affect the respiratory system. Smokers have an increased risk of respiratory effects.
Signs and symptoms of exposure: Irritation to the skin, eyes, nose and throat may occur. Some people may occasionally experience coughing.
Medical conditions generally aggravated by exposure: Allergies and respiratory ailments.

Section 12: Ecological Information: (Non-Mandatory)

Section 13: Disposal Considerations: (Non-Mandatory)

Section 14: Transport Information: (Non-Mandatory)

Section 15: Regulatory Information: (Non-Mandatory)

Section (B)(5)(III) of the HCS (CFR 1910.1200) exempts food, including feed and therefore any associated feed ingredient dust, from the labeling requirements of the HCS since the food/feed ingredient is subject to the labeling requirements of the FDA.

Section 16: Other information

General: All electrical equipment must be suitable for use in hazardous atmospheres involving combustible dust in accordance with 29 CFR 1910.307. The National Electric Code, NFPA 70, contains guidelines for determining the type and design of equipment and installation, which will meet this requirement.

MATERIAL SAFETY DATA SHEET

Section 1. Company Identification and Product Information			
Product Name or Identity:	**Skim Milk**		
Manufacturer's Name:	Acumedia Manufacturers, Inc.	**Emergency Phone No.:**	517/372-9200
	740 East Shiawassee	**Fax No.:**	517/372-0108
	Lansing, Michigan 48912	**e-mail:**	foodsafety@neogen.com
Date Prepared or Revised: November 2007			

Section 2. Composition / Information on Ingredients				
Hazardous Components Specific Chemical Identity:	**CAS-No.**	**%**	**EG-Number**	**Hazard Symbol**
This product contains no hazardous constituents, or the concentration of all chemical constituents are below the regulatory threshold limits described by Occupational Safety Health Administration Hazard Communication Standard 29 CFR 1910.1200 and the European Directive 91/155/EEC, and 93/112/EC.	N/A	N/A	N/A	N/A

Section 3. Health Hazard Identification			
Route(s) of Entry:	Inhalation? Yes	Skin? Yes	Ingestion? Yes
Health Hazards: *(Acute and Chronic)*	No irritating effect. When used and handled according to specifications, the product does not have harmful effects according to the information provided to us. May cause minor irritation of the eyes and skin.		
Carcinogenicity:	IARC Monographs? No	OSHA Regulated? No	
Signs and Symptoms of Exposure: No irritating effect, however contact may cause a mild irritation.			
Medical Conditions Generally Aggravated by Exposure: No sensitizing effects known.			

Section 4. First Aid Measures	
Emergency / First Aid Procedures:	Ingestion: If swallowed, wash out mouth with water, provided person is conscious. Never give anything by mouth to an unconscious person. Seek medical attention.
	Inhalation: If inhaled, supply fresh air or oxygen. Seek medical attention.
	Eye Contact: Rinse opened eye for at least 15 minutes under running water, lifting lower and upper eyelids occasionally. Seek medical attention.
	Skin Contact: Remove contaminated clothing. Immediately wash with plenty of soap and water for at least 15 minutes. Seek medical attention if irritation develops.

Section 5. Fire and Explosion Hazard Data	
Flash Point (Method Used): N/A	**Flammable Limits**: LEL – N/A UEL – N/A
Extinguishing Media: Use alcohol foam, dry chemical, or carbon dioxide. Water may be ineffective.	
Special Fire Fighting Procedures: Firefighters should wear protective equipment and self-contained breathing apparatus. The product itself does not burn.	
Unusual Fire and Explosion Hazards: During heating or in case of fire, poisonous gases are produced. Fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source, is a potential dust explosion hazard.	

Section 6. Accidental Release Measures
Personal Precautions: Shut off all sources of ignition, ventilate spill area. Wear suitable protective clothing, gloves, and eye protection. Wear self-containing breathing apparatus, rubber boots, and heavy rubber gloves. Place contaminated material in a chemical waste container.
Environmental Precautions: Prevent dispersion of material. Do not allow to enter drains or water courses. Water runoff can cause environmental damage.
Clean-up Methods: Contact safety officer if questions arise. Ventilate area. Absorb spill with inert material, including dry-lime, sand, or soda ash, then place into a chemical waste container using non-sparking tools. Wash spill site.

Section 7. Handling and Storage
Handling: Protect against physical damage. Ensure good ventilation / exhaustion. Avoid contact with eyes, skin, and clothing. Avoid prolonged or repeated exposure. Do not use if skin is cut or scratched.
Storage: Keep container tightly closed. Keep away from incompatible material. Storage area should be cool, dry and well ventilated.
Other Precautions: Remove contaminated clothing immediately. Ensure good ventilation. Prevent dust formation.

Section 8. Exposure Controls / Personal Protection		
OES: N/A		**ACGIH TLV:** N/A
Engineering Measures: Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU). Proper ventilation, safety shower, and eye bath required.		
Respiratory Protection (Specify Type)**:** With sufficient ventilation, breathing apparatus is not necessary. In the event of possible spill / exposure, use dust mask to EN 149 FFP2S.		
Ventilation:	**Local Exhaust:** 50 – 100 CFM	**Special:** Safety shower and eye wash.
Protective Gloves: Compatible chemical-resistant gloves.		**Eye Protection:** Safety glasses or chemical goggles to EN 166, 167, and 168.
Other Protective Clothing or Equipment: Uniform, lab coat, or disposable lab wear.		
Work / Hygienic Practices: Follow the usual precautionary measure for handling chemicals / powder. Keep away from food and beverages. Immediately remove all soiled and contaminated clothing. Avoid contact with eyes, skin, and clothing.		

Section 9. Physical and Chemical Properties	
Boiling Point: N/A	**Specific Gravity:** N/A
Vapor Pressure: N/A	**Melting Point:** N/A
Vapor Density (AIR = 1): N/A	**Solubility in Water:** N/A
Appearance and Odor: N/A	

Section 10. Stability and Reactivity			
Stability:	Unstable		
	Stable	X	Conditions to Avoid: Stable under recommended storage conditions.
Incompatibility *(Materials to Avoid)***:** Incompatible with strong oxidizing agents.			
Hazardous Decomposition or Byproducts: N/A			
Hazardous Polymerization:	May Occur		
	Will Not Occur	X	Conditions to Avoid: No dangerous reactions known.

Section 11. Toxicological Information

When used and handled according to specifications and according to information provided for us, this product does not have any harmful effects.

Section 12. Ecological Information

Ecotoxicity Tests: The ecological effects have not been thoroughly investigated, but currently none have been identified.

Section 13. Disposal Considerations

Waste Disposal Method: Dispose in accordance with all applicable federal, state, and local environmental regulations. Keep waste separate. Contact a licensed professional waste disposal service to dispose of this material if questions arise.

Container Information: Do not remove labels from containers until they have been cleaned.

Section 14. Transport Information

UN # --*
Class: --
Packing Group: --
Hazard Class: --
IATA: Non-Hazardous for Air Transport
*This product is not regulated for transportation.

Section 15. Regulatory Information

EU Regulations

Not Applicable.

Section 16. Other Information

This document is believed to be correct, but does not purport to be all inclusive and shall be used only as a guide. Acumedia Manufacturers, Inc. shall not be held liable for any damage resulting from handling or from contact with the above product. These suggestions should not be confused with state, municipal or insurance requirements, and constitute NO WARRANTY.

Water

Safety Data Sheet

according to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 / Rules and Regulations

Date of issue: 11/15/2013 Revision date: 06/12/2018 Supersedes: 01/25/2017 Version: 1.3

SECTION 1: Identification

1.1. Identification

Product form : Substance

Substance name : Water

CAS-No. : 7732-18-5

Product code : LC26750

Formula : H2O

1.2. Recommended use and restrictions on use

Use of the substance/mixture : For laboratory and manufacturing use only.

Recommended use : Laboratory chemicals

Restrictions on use : Not for food, drug or household use

1.3. Supplier

LabChem Inc
Jackson's Pointe Commerce Park Building 1000, 1010 Jackson's Pointe Court
Zelienople, PA 16063 - USA
T 412-826-5230 - F 724-473-0647
info@labchem.com - www.labchem.com

1.4. Emergency telephone number

Emergency number : CHEMTREC: 1-800-424-9300 or +1-703-741-5970

SECTION 2: Hazard(s) identification

2.1. Classification of the substance or mixture

GHS-US classification

Not classified

2.2. GHS Label elements, including precautionary statements

Not classified as a hazardous chemical.

Other hazards not contributing to the classification : None.

2.4. Unknown acute toxicity (GHS US)

Not applicable

SECTION 3: Composition/Information on ingredients

3.1. Substances

Substance type : Mono-constituent

Name	Product identifier	%	GHS-US classification
Water (Main constituent)	(CAS-No.) 7732-18-5	100	Not classified

Full text of hazard classes and H-statements : see section 16

3.2. Mixtures

Not applicable

SECTION 4: First-aid measures

4.1. Description of first aid measures

First-aid measures general : If you feel unwell, seek medical advice (show the label where possible).

First-aid measures after inhalation : Allow victim to breathe fresh air. Allow the victim to rest. Adverse effects not expected from this product.

First-aid measures after skin contact : Adverse effects not expected from this product. Take off contaminated clothing.

First-aid measures after eye contact : Adverse effects not expected from this product.

First-aid measures after ingestion : Do NOT induce vomiting. Adverse effects not expected from this product.

4.2. Most important symptoms and effects (acute and delayed)

Symptoms/effects : Not expected to present a significant hazard under anticipated conditions of normal use.

4.3. Immediate medical attention and special treatment, if necessary

Treat symptomatically.

SECTION 5: Fire-fighting measures

5.1. Suitable (and unsuitable) extinguishing media

Suitable extinguishing media : Foam. Dry powder. Carbon dioxide. Water spray. Sand.

5.2. Specific hazards arising from the chemical

No additional information available

5.3. Special protective equipment and precautions for fire-fighters

Firefighting instructions : Use water spray or fog for cooling exposed containers. Exercise caution when fighting any chemical fire.

Protection during firefighting : Do not enter fire area without proper protective equipment, including respiratory protection.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. For non-emergency personnel

Emergency procedures : Evacuate unnecessary personnel.

6.1.2. For emergency responders

Protective equipment : Equip cleanup crew with proper protection.

Emergency procedures : Ventilate area.

6.2. Environmental precautions

Prevent entry to sewers and public waters. Notify authorities if liquid enters sewers or public waters.

6.3. Methods and material for containment and cleaning up

Methods for cleaning up : Soak up spills with inert solids, such as clay or diatomaceous earth as soon as possible.

6.4. Reference to other sections

See Heading 8. Exposure controls and personal protection.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Wash hands and other exposed areas with mild soap and water before eating, drinking or smoking and when leaving work.

7.2. Conditions for safe storage, including any incompatibilities

Storage conditions : Keep container closed when not in use.

Incompatible products : Metallic sodium.

Incompatible materials : Sources of ignition. Direct sunlight.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

No additional information available

8.2. Appropriate engineering controls

Appropriate engineering controls : Provide adequate general and local exhaust ventilation.

8.3. Individual protection measures/Personal protective equipment

Personal protective equipment:

Gloves. Safety glasses.

Hand protection:

Wear protective gloves.

Eye protection:

Chemical goggles or safety glasses

Respiratory protection:

None necessary.

Other information:

Do not eat, drink or smoke during use.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Liquid
Color	:	Colorless
Odor	:	None.
Odor threshold	:	No data available
pH	:	7
Melting point	:	0 °C
Freezing point	:	No data available
Boiling point	:	100 °C
Critical temperature	:	374.1 °C
Critical pressure	:	218.3 atm
Flash point	:	No data available
Relative evaporation rate (butyl acetate=1)	:	No data available
Flammability (solid, gas)	:	Non flammable.
Vapor pressure	:	17.535 mm Hg
Vapor pressure at 50 °C	:	92.51 mm Hg
Relative vapor density at 20 °C	:	No data available
Relative density	:	1
Specific gravity / density	:	0.99823 g/ml
Molecular mass	:	18 g/mol
Solubility	:	Soluble in acetic acid. Soluble in acetone. Soluble in ammonia. Soluble in ammonium chloride. Soluble in ethanol. Soluble in glycerol. Soluble in hydrochloric acid. Soluble in methanol. Soluble in nitric acid. Soluble in sulfuric acid. Soluble in sodium hydroxide solution. Soluble in propylene glycol.
Log Pow	:	No data available
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Viscosity, kinematic	:	1.004 cSt
Viscosity, dynamic	:	1.002 cP
Explosion limits	:	No data available
Explosive properties	:	Not applicable.
Oxidizing properties	:	None.

9.2. Other information

VOC content : 0 %

SECTION 10: Stability and reactivity

10.1. Reactivity

No additional information available

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

Not established.

10.4. Conditions to avoid

Extremely high or low temperatures.

10.5. Incompatible materials

Metallic sodium.

10.6. Hazardous decomposition products

Hydrogen. oxygen.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Likely routes of exposure : Skin and eye contact

Acute toxicity : Not classified

Water (7732-18-5)	
LD50 oral rat	≥ 90000 mg/kg
ATE US (oral)	90000 mg/kg body weight

Skin corrosion/irritation : Not classified
pH: 7

Serious eye damage/irritation : Not classified
pH: 7

Respiratory or skin sensitization : Not classified

Germ cell mutagenicity : Not classified

Carcinogenicity : Not classified
(Based on available data, the classification criteria are not met)

Reproductive toxicity : Not classified

Specific target organ toxicity – single exposure : Not classified

Specific target organ toxicity – repeated exposure : Not classified

Aspiration hazard : Not classified

Potential Adverse human health effects and symptoms : Based on available data, the classification criteria are not met.

SECTION 12: Ecological information

12.1. Toxicity

No additional information available

12.2. Persistence and degradability

Water (7732-18-5)	
Persistence and degradability	Not established.

12.3. Bioaccumulative potential

Water (7732-18-5)	
Bioaccumulative potential	Not established.

12.4. Mobility in soil

No additional information available

12.5. Other adverse effects

Other information : No other effects known.

SECTION 13: Disposal considerations

13.1. Disposal methods

Waste disposal recommendations : Dispose in a safe manner in accordance with local/national regulations.

SECTION 14: Transport information

Department of Transportation (DOT)

In accordance with DOT

Not regulated

SECTION 15: Regulatory information

15.1. US Federal regulations

Water (7732-18-5)
Listed on the United States TSCA (Toxic Substances Control Act) inventory

All components of this product are listed, or excluded from listing, on the United States Environmental Protection Agency Toxic Substances Control Act (TSCA) inventory

15.2. International regulations

CANADA

No additional information available

EU-Regulations

No additional information available

National regulations

No additional information available

15.3. US State regulations

California Proposition 65 - This product does not contain any substances known to the state of California to cause cancer, developmental and/or reproductive harm

SECTION 16: Other information

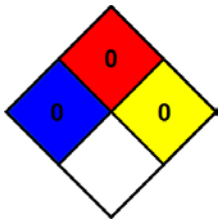
Revision date : 06/12/2018

Other information : None.

NFPA health hazard : 0 - Materials that, under emergency conditions, would offer no hazard beyond that of ordinary combustible materials.

NFPA fire hazard : 0 - Materials that will not burn under typical fire conditions, including intrinsically noncombustible materials such as concrete, stone, and sand.

NFPA reactivity : 0 - Material that in themselves are normally stable, even under fire conditions.



Hazard Rating

Health : 0 Minimal Hazard - No significant risk to health

Flammability : 0 Minimal Hazard - Materials that will not burn

Physical : 0 Minimal Hazard - Materials that are normally stable, even under fire conditions, and will NOT react with water, polymerize, decompose, condense, or self-react. Non-Explosives.

Personal protection : A

A - Safety glasses

SDS US LabChem

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