

## Cheese and Cheese Analogues

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### ABSTRACT

*Milk consists about 87% water and 13% total solids of which 4% is fat, 3.4% protein, 4.8% lactose and 0.8% minerals such as calcium, magnesium, etc. Milk and milk products have been consumed as food since prehistoric days. Cheese-making was discovered accidentally in Iraq where it was initially developed. The cheese yield via acidification of lactic acid produced by bacteria during milk fermentation or rennet coagulation or combination of both is about 11% to 15%. Cheese varieties are classified by their hardness which varies according to their moisture contents. The increasing price trend of dairy cheese is now encouraging the manufacture of cheese analogues as an effective alternative for the culinary industry. The principal fatty acids found in milk triglycerides suggest that palm oil could be used as a butterfat substitute in cheese analogue formulation.*

### INTRODUCTION

Milk is an emulsion or a colloid of butterfat globules within a water-based fluid the molecular structure of which is shown in Figure 1. Protein molecules in the milk act

as surfactants forming micelles around the particles of fat and the negative surface charges keeps the milk in liquid emulsion state. Each fat globule is surrounded by a membrane consisting of phospholipids and proteins. The fat soluble vitamins A, D, E and K are found within the fat portion of the milk (McGee, 2004). Table 1 shows the typical nutritional values of cow's milk. If the pH level of the milk decreases, amino acids at the surface of the proteins begin losing its charge and become neutral, turning the fat micelles from hydrophilic to hydrophobic state causing the liquid to coagulate.

Cheese is a generic term assigned for a nutritious food made from coagulation of mostly dairy milk protein casein since about 4000 years ago. Cheese is now produced throughout the world in wide ranging flavours, textures and forms depending on the origin of the milk including the animal's diet, the butterfat content, pasteurisation and the microorganism used, the processing and aging. Herbs, spices or wood smoke may be used as flavouring agents. The yellow to red colour of many cheeses is changed by adding annatto to cheese. Most cheeses melt at cooking temperatures. Cream cheese, cheddar and mozzarella are some of the well-known types of cheese (Barbara, 1981).

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Although milk could be curdled by adding acids such as vinegar or lemon juice to produce a few types of cheese, most cheeses are produced from lactic acid bacteria by anaerobic homolactic fermentation at about 23°C which turn milk sugars into lactic acid as shown in the reaction below. This is then followed by the addition of the enzyme rennet originally made from calf stomachs to produce a harder curdling (Anestis, 2006). The process requires several ripening steps at lower temperatures and a curd cooking step at a higher temperature because both the bacteria and rennet can be destroyed by temperature.



Vegetarian rennet is mostly produced by the fermentation of the fungus *Mucor miehei*, but some have been extracted from various species of the *Cynara* thistle family.

Hard cheese requires curds pressed in a cheese press to drain off more water than

the soft cheese before the pressed cheese is dried and stored for aging for several months (Jenkins, 1996).

Cheese is valued for its potability, long shelf-life, high content of fat, protein, calcium and phosphorus. Cheese makers near a dairy region may benefit from fresh, low priced milk and low shipping costs. The long storage life of some cheese especially if it is encased in a protective rind, allows selling when markets are favourable. The first American cream cheese was made in Chester, New York by dairyman William Lawrence in 1872. The city Philadelphia was considered to be the home of top quality food in the USA and was adopted as the brand name in 1880 and it remains the most widely recognised brand of cream cheese. The company was eventually bought over by Kraft Foods in 1928 (Kraft, 2010).

The following simple recipe for producing a delicious small curd cottage cheese that resembles ricotta is excellent for use in Italian dishes such as lasagne.

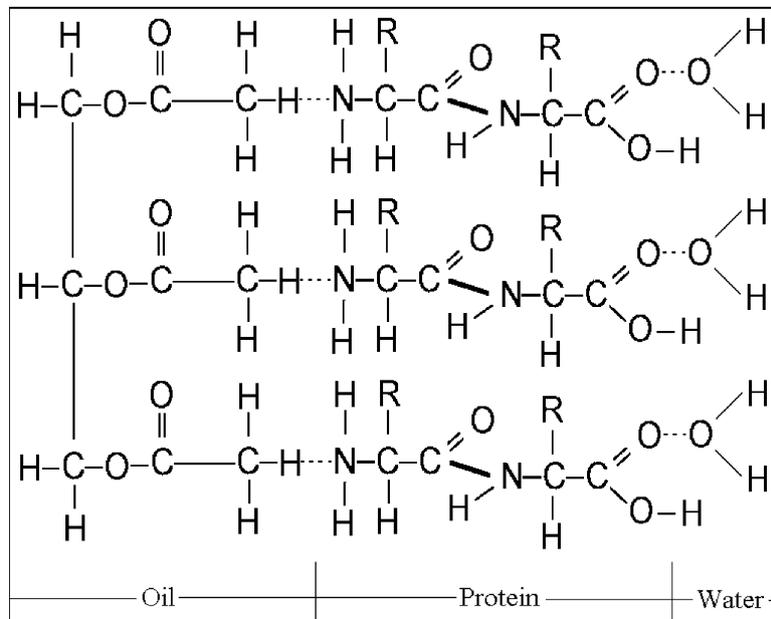


Figure 1. Typical colloid molecule structure (schematic).

**TABLE 1. USDA DATABASE FOR NUTRITIONAL VALUE PER 100 g OF COW'S MILK (whole)**

Energy	252 kJ
Carbohydrates (lactose)	5.26 g
Fat	3.25 g
• Saturated	1.865 g
• Monounsaturated	0.812 g
• Polyunsaturated	0.195 g
Protein	3.22 g
• Tryptophan	0.075 g
• Threonine	0.143 g
• Isoleucine	0.165 g
• Leucine	0.265 g
• Lysine	0.140 g
• Methionine	0.075 g
• Cystine	0.017 g
• Phenylalanine	0.147 g
• Tyrosine	0.152 g
• Valine	0.192 g
• Arginine	0.075 g
• Histidine	0.075 g
• Alanine	0.103 g
• Aspartic acid	0.237 g
• Glutamic acid	0.648 g
• Glycine	0.075 g
• Proline	0.342 g
• Serine	0.107 g
Water	88.32 g
Vitamin A equivalence	28 $\mu$ g
Thiamine (vitamin B <sub>1</sub> )	0.044 mg
Riboflavin (vitamin B <sub>2</sub> )	0.183 mg
Vitamin B <sub>12</sub>	0.44 $\mu$ g
Vitamin D	40 IU
Calcium	113 mg
Magnesium	10 mg
Potassium	143 mg
Sodium	43 mg
Density	1030 kg m <sup>-3</sup>





### Ingredients:

4 litres of fresh milk, 150 ml of vinegar and 1 g of salt.

### Method:

Heat the milk to about 90°C followed by the addition of vinegar. Allow the mixture to cool to room temperature of about 28°C and pour it into a colander to drain off the whey. Transfer the curds into a bowl, sprinkle salt and mix well.

### DAIRY CHEESE PRICE TREND

The calculated world market price for milk ranged between USD 10 per tonne to USD 25 per tonne during the period 1981 to 2005. However, it increased rapidly by 75% to more than USD 45 per tonne in 2007 as a result of the demand for skimmed milk powder (SMP) and butter from USD 1000 per tonne and USD 2000 per tonne respectively to USD 4000 per tonne in response to a shortfall in milk availability based on world demand.

In the past, increases in demand were driven mainly by population growth, whereas they are now increasingly fuelled by rising per capita milk consumption in developing countries. The deficit in world milk production since 2004 did not have a major effect on prices at first as additional supplies of about 2 million tonnes per year were available from stocks in the USA and the European Union. However, prices increased dramatically when these supplies were exhausted. Climatic events and policy interventions could have been determinantal to this price escalation. The main countries where there is milk surplus are Argentina, Australia, New Zealand, USA, Uruguay European Union and Eastern Europe. During the period 1990 to 2004, overall milk exports increased from 4.0% to 7.1% of total production while the share delivered to formal milk processors increased from 14% to 24% (IFCN, 2008).

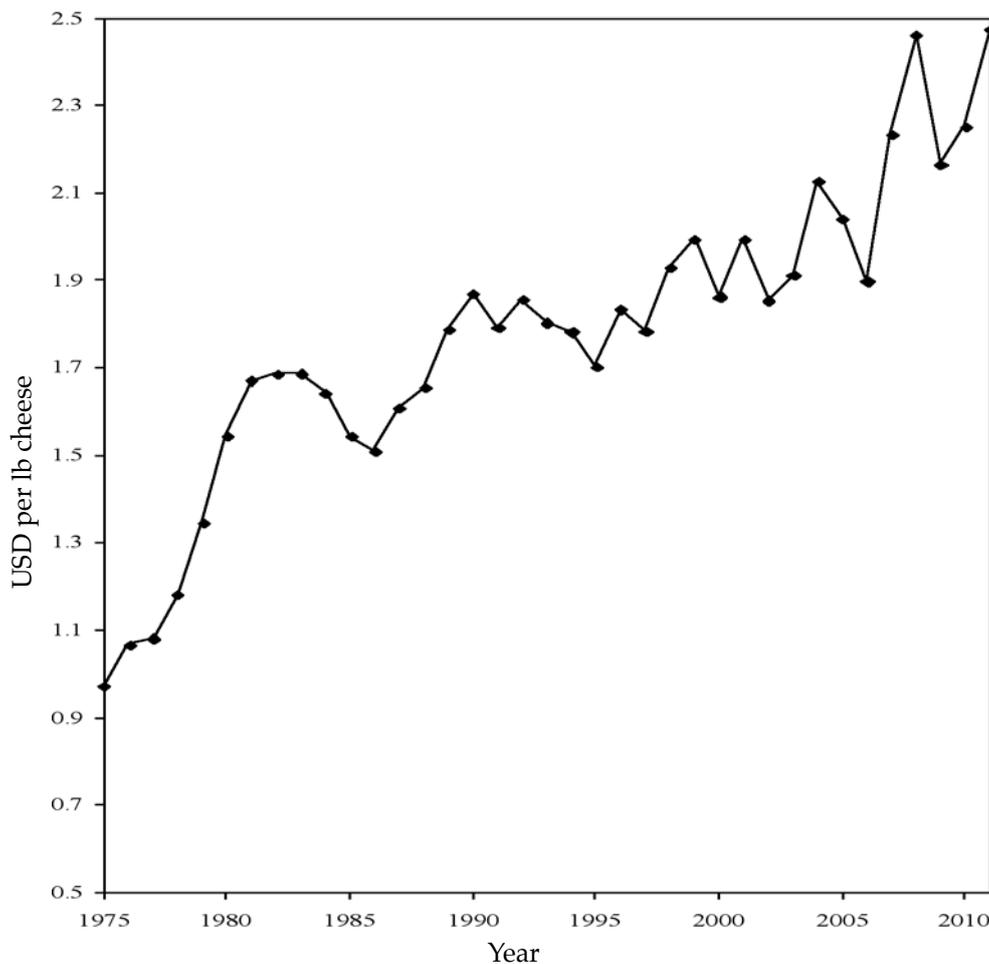
Since the price of milk which is the main ingredient of cheese recently rose significantly, the price of cheese also rose in tandem with the milk. *Figure 2* shows the wholesale price trend for mozzarella cheese which is one of the main ingredients in pizza baking (Brian Gould, 2011). Thus, cheap cheese analogues need to be developed to satisfy the culinary demand especially in low per capita income countries.

### CHEESE ANALOGUES

Cheese analogues or cheese substitutes are available as cheese counterparts in most nations in Asia. They are made from soyabeans, rice, almonds, nutritional yeast and other non-dairy products. These products are usually consumed due to certain dietary preferences, such as vegetarianism, religious restrictions such as kosher (fulfilling the requirements of Jewish law) or *halal* requirements and lactose intolerance or allergies.

Fat contributes to a creamy mouth feel which was the precursor for the development of the present cheese structure. The fat particles interrupt the protein matrix and prevent cheese from getting too solid, an important factor for the development of flavour during aging. The use of vegetable fat such as palm oil during cheese production may optimise the fatty acid profile and reduce the cholesterol content. Basically, there are three possibilities as mentioned (Mellgren, 2003):

- partial or complete substitution of milk fat with vegetable fat by using skimmed milk and vegetable fat;
- complete substitution of milk fat with vegetable fat by using whey proteins, water and vegetable fat; or
- replacement of all milk components with vegetable products for the production of vegetarian cheese alternatives made from vegetable proteins, microbial rennet and vegetable fat.



Source: Brian Gould (2011).

Figure 2. Wholesale price trend for mozzarella cheese.

The common ingredients for white cheddar cheese analogues with approximately 18.4% total fat content are water, potato starch, non-hydrogenated vegetable fats and oils, soya protein, yeast extract, carrageen as a thickener, salt, flavouring and carotene. The common ingredients for super-melting mozzarella cheese analogues with approximately 25.4% total fat content are water, non-hydrogenated vegetable fats and oils, soya protein, starch, carrageen and locust bean gum as thickeners, salt, yeast extract, calcium phosphate and potassium phosphate as emulsifying salts, raw cane sugar, flavour, herbs, spices, annatto and beta carotene.

The following simple recipe produces a delicious cheese substitute suitable as a cream cheese spread on crackers, creamy spread on sandwich bread, replacing ricotta in any culinary recipes or serve it warm as a cheesy appetizer in 1 hr.

#### Ingredients:

65 g of nutritional yeast, 65 g of soyamilk powder, 250 ml of soyamilk, 5 ml of vinegar, 10 ml of prepared spicy mustard, 360 ml of tofu and salt to taste.



### Preparation:

Pre-heat oven to 180°C and set aside a non-stick 8" round cake pan. The nutritional yeast and soyamilk powder are mixed in a small saucepan followed by soyamilk and heat over medium heat to homogenise the powder. While stirring continuously add the vinegar, mustard and salt and cook until the mixture thickens before removing from the cooker. The soyabean cake or taufu is processed in a blender or food processor until creamy followed by adding the soyamilk mixture carefully to process until well combined. Pour into cake pan and bake for 35 min to 40 min, or until cheese has a golden skin, but still feels creamy in the centre when you press its surface. Remove from oven to cool on a cooling rack. Cheese can be chilled in the refrigerator.

### DISCUSSION AND CONCLUSION

Analogue cheeses were introduced in the US in early 1970s. Cheese alternatives were then being produced and sold in USA, United Kingdom, Sweden, France, Germany, Belgium, Switzerland and Australia (Rupesh and Atanu, 2007). Manufacture of analogue cheese involves blending selected ingredients together and heating to produce stable molten oil in water emulsion which sets on cooling. There are four key ingredients needed to manufacture analogue cheese namely water, emulsifying salts, protein and fat (Adnan Tamime, 2011). The texture and the flavour profile of analogue cheese are determined by the selected types of protein, oil, starch, hydrocolloid, emulsifiers and emulsifying salts (Gerstenberg Schröder, 2010). Cheese substitutes produced from casein or soyamilk usually require enrichment with nutritional ingredients in order to become comparable to natural cheese and are rarely characterised by a satisfactory taste.

New technologies bridge the gap between analogue and natural cheese products. Indistinguishable cheese analogue can be produced by heat treatment of milk proteins with addition of vegetable oil mixture without using starter bacteria. The process has been developed based on a series of physio-chemical and biochemical principles which is high yield without generating whey, fast, simple, consistent and cost-effective of approximately half the cost compared to natural cheese production. The flavour matching natural cheese is achieved by addition of enzymes contained in natural cheese ingredients to the cheese base separately without need for ripening. The texture of the final product is controlled through the level of moisture and the use of texturisers. The product is ready for the market in 24 hr.

Food service and industrial companies have been turning to cheese analogue products for a number of years due to its attractive price and functionality. A product then considered as high end would be lucky to fall in the mid-range today. According to Information Resources Incorporation scanner data grocery retail sales in 2006 were 34.1 million pounds. The Wisconsin Milk Marketing Board's Foodservice Cheese Tracker shows that 76% of cheese analogue is used by full service restaurants, 19% non-commercial use and remaining 5% for leisure or retail purposes. Wide varieties of flavours are available in blocks, shreds, slices or sauces. According to the Mintel Global New Products Database, cheese analogue has been featured in a number of new products released in the US (Amelia Buragas, 2007).

Cheese analogues have not made significant impact yet on the retail market but are predicted to compete with dairy cheese on an increasing scale due to the consumers' preferences in demanding low cholesterol, low saturated fats and low

calorie foodstuffs with ingredients that help to lower health risks via substituting animal fats by vegetable oils and fats (Hans-Peter Bachmann, 2001).

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