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Characteristics and Technological Aspects of the Egyptian Cheeses

Ahmed R. A. Hammam^{1,2*}, Mohamed S. Elfaruk¹,
Mahmoud E. Ahmed² and Venkateswarlu Sunkesula¹

¹Dairy and Food Science Department, South Dakota State University,
Brookings 57007, SD, USA

²Dairy Science Department, Faculty of Agriculture, Assiut University, Assiut, Egypt

*Corresponding author

ABSTRACT

Cheese is a dairy product produced by precipitating the casein of milk using starter cultures and rennet (*e. g.* enzymes) through a chemical process. Cheese is different among countries and could be made from cow's, buffalo's, goat's, sheep's, or camel's milk. Cheese is a good source of protein and minerals (such as calcium and phosphorus) that have nutritional values. Cheese is also essential for building healthy bones and teeth and provide the brain with essential fatty acids. Different technologies and different milk have been utilized to manufacture the traditional Egyptian cheeses, which resulted in differences in the composition, cheese types, and flavors. Consequently, this work aims to review and highlight the technological and chemical aspects of the most popular Egyptian cheese varieties, namely, Domiati cheese, Karish cheese, Mish cheese, and Ras cheese made from different sources of milk during ripening; and to briefly discuss the health benefits of the cheese.

Keywords

Cheese composition, Domiati cheese, Karish cheese, Mish cheese, Ras cheese

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Introduction

Cheese is a preserved form of milk that can be obtained by using starter cultures and enzymes to coagulate the milk through a chemical process in several steps, as shown in Figure 1 (Fox and McSweeney, 2004; Hammam *et al.*, 2018; Wolfschoon, 2010). Cheese is well known for its nutritional value

and longevity; however, it has different tastes, textures, and styles depending on many parameters, such as the starter cultures, the type of milk, the ripening or aging, and the manufacturing conditions.

Cheese can be made from cow's, buffalo's, camel's, goat's, and sheep's milk. Cheese is divided into three main categories, including

soft cheese, semi-hard cheese, and hard cheese. The soft cheese is un-ripened, made locally from sour milk, and consumed on the same day of processing. The medium or semi-hard cheese is not consumed widely compared to the soft and hard cheese. The hard cheese is ripened by rennet enzymes (Hellmuth and van den Brink, 2013) or bacteria.

There are many varieties of cheese in Egypt, such as Domiati cheese and Karish cheese (soft cheeses), Mish cheese (pickled cheese), and Ras or Roumy cheese (hard cheese), which are widely consumed and produced in Egypt, Arab countries, and Mediterranean countries. Cheese is a rich source of calcium and protein. It also contains large quantities of vitamins A, B₁₂, zinc, and phosphorus. Cheese is essential to the body because of its critical role in building the bones and teeth and providing the brain with essential fatty acids.

This review aims to present the technological and chemical properties of the most common traditional cheeses in Egypt; additionally, some of the health benefits of these cheeses to the human body.

Domiati cheese

Domiati cheese is a soft cheese and consumed widely in Egypt, Arab countries, Mediterranean countries, and Europe. Domiati cheese name was related to the governorate of Damietta (Abou-Donia, 1996) which is similar to Greece Feta cheese. Domiati cheese originated in Egypt in 332 BC (Abou-Donia, 1996). Domiati cheese was studied by many researchers in Egypt (Ayad, 2009; El-Baradei *et al.*, 2007a; A. H. Fahmi and Sharara, 1950) and other countries, *e.g.*, Denmark, Germany, India, Iraq, Libya, New Zealand, USA, and USSR (Abou-Donia, 1996; El-Baradei *et al.*, 2007b). The quality

of Domiati cheese is high when it is manufactured from buffalo's milk due to the high solids content of buffalo's milk (15-17% solids) compared to bovine's milk (12-14% solids). Domiati cheese was manufactured from different varieties of milk, such as cow's milk (Fahmi *et al.*, 1973; Fahmi and Sharara, 1950; Ibrahim *et al.*, 1974; Ismail *et al.*, 2010; Sharara, 1961a; Youssef *et al.*, 1982a), buffalo's milk (Fahmi *et al.*, 1973; A H Fahmi and Sharara, 1950; Ibrahim *et al.*, 1974; Ismail *et al.*, 2011; Rakshy and Attia, 1979; Sharara, 1961b; Youssef *et al.*, 1982b), goat's milk (Mehaia, 2002; Rakshy and Hassan, 1971a), and camel's milk (Mehaia, 2006, 1993).

Manufacturing of Domiati cheese

Salt is added (8-15%) to the milk, and then the rennet is added at 38°C. Once the milk is coagulated (2-3 h), the curd is cut and ladled into molds and left between 12-24 h to drain the whey. The Domiati cheese is served fresh as it is after manufacturing or pickled in pickling solutions (Abd El-Salam *et al.*, 1993; Abou-Donia, 1996). Pasteurization and adding starter cultures are recently utilized to keep the typical flavor of Domiati cheese and avoid adding an extensive quantity of salt as a preservative (Abd El-Salam *et al.*, 1993; Abou-Donia, 1996). Adding single or a coculture of lactococci, lactobacilli, and enterococci was used in making Domiati cheese by many researchers (Abou-Donia, 1996). The Domiati pH is ranged from 6.0 to 6.5 (Abd El-Salam *et al.*, 1993). Lactic acid bacteria (LAB) microflora (*e.g.*, lactococci and lactobacilli) was found and isolated from the Domiati cheese surface. *Lactococcus lactis* subsp *lactis*, *Lactobacillus casei*, and *Lactobacillus delbrueckii* subsp *bulgaricus* were the main species of LAB isolated from Domiati cheese surface (Abou-Donia, 1996). Adding 7.5% of salt to the milk resulted in the presence of lactococci as the predominant of

LAB in Domiati cheese, which is recently substituted by lactobacilli (Litopoulou-Tzanetaki, 2007). Increasing the addition of salt to 15% led to the presence of micrococci and lactobacilli as the majority of LAB. Enterococci were isolated from Domiati cheese, which exhibits high esterolytic activities (Hemati *et al.*, 1997; Litopoulou-Tzanetaki, 2007).

Abou-Donia (1996) informed that the acidity of milk, starter cultures, milk treatments, additives, ripening, and storage temperatures affect the flavor of Domiati cheese. The soluble proteolysis products resulted from the Domiati cheese during ripening mixed with the brine to keep the stability with their content in the cheese (Abd El-Salam *et al.*, 1993; Hayaloglu, 2017).

The composition of Domiati cheese

The moisture, fat, protein, and salt contents of Domiati cheese obtained from cow's milk, buffalo's milk, mixed of cow's and buffalo's milk, goat's milk, and camel's milk are shown in Figure 2. The moisture content of Domiati cheese made from cow's milk decreased from 59 to 55% during 4-6 months of maturation or ripening period (A H Fahmi and Sharara, 1950). The moisture content of Domiati cheese that manufactured from different types of milk decreased due to the loss of the moisture content into the brine during the ripening period (El-Koussy *et al.*, 1977; A H Fahmi and Sharara, 1950; Ismail *et al.*, 2011; S. Rakshy and Attia, 1979; Rakshy and Hassan, 1971b). However, fat, protein, and salt contents of Domiati cheese increased with increasing the dry matter during the ripening period (Fahmi and Sharara, 1950; Ismail *et al.*, 2011; Rakshy and Attia, 1979; Rakshy and Hassan, 1971b). The pH of Domiati cheese decreased during the ripening or storage period. The pH of Domiati cheese made from cow's and buffalo's mixture using rennet as a coagulant decreased from 6.7 to

3.8 during the 4 months of ripening (Abdou *et al.*, 1976). The pH of Domiati cheese that manufactured from cow's milk and whey proteins and ultrafiltered buffalo's milk decreased from 6.6 to 4.6 and 6.7 to 4.4, respectively (Abd El-Salam *et al.*, 1981; El-Shibiny *et al.*, 1973). The calcium and phosphorus contents of Domiati cheese obtained from cow's milk after manufacturing (fresh) were 0.96% and 0.70%, respectively, and these values were approximately the same after 2 M of ripening 0.96% and 0.69, respectively (Omar and Buchheim, 1983). The calcium and phosphorus percentages were 0.59% and 0.14%, respectively, after the manufacturing of Domiati cheese from cow's and buffalo's milk mixture (Sharara, 1956). The composition of Domiati cheese varies based on the types of milk, coagulation method, the age of cheese, additives, and conditions of cheese manufacture (Abou-Donia, 1996).

Karish cheese

The Karish cheese is also soft, has known by the ancient Egyptians, and could be manufactured from skim cow's or buffalo's milk or a mixture of both (Abou-Donia, 1996). Karish cheese is traditionally manufactured from skim milk, so fat is separated by pouring the milk in pots known as Matrad or Shalia (Figure 2) and left in a warm place till the fat is separated and floated on the surface and the milk gets fermented or coagulated (Abou-Donia, 1996). The fat or cream is separated to produce butter oil while the fermented milk is consumed as it is (called Laban Rayeb) or to make Karish cheese which is consumed fresh or stored for more than one year to produce Mish cheese (Abou-Donia, 1984, 1996).

The earthenware pots made in the First Dynasty by the ancient Egyptians in 3200 BC and detected recently in the tomb of King Horaha. Also, mats or Shenda (Figure 3),

which is commonly used to drain Karish cheese whey, and Zallaa or Ballas (Figure 4) which are used to store and pickle Mish cheese, were found in the temples of the Roman era (Engelbach, 1946). All of these clues prove that the Mish and Karish cheeses were known to the ancient Egyptians.

Karish cheese is an acid cheese which widely produced and consumed in the rural districts in Egypt (El-Gendy, 1983). Karish cheese is a white, soft cheese and has approximately 70% and 10% of moisture and fat contents, respectively. Karish cheese could be produced from Laban Rayeb, fresh skim milk, and buttermilk. It is served fresh or stored in a pickling solution in Ballas to produce Mish cheese (Abou-Donia, 1984, 1996; El-Gendy, 1983). Karish cheese has been investigated by many researchers and made from several varieties of milk, such as cow's milk (Abou-Dawood and Gomai, 1977; El-Sadek and Abd-El-Motteleb, 1958; El-Sadek and Motteleb, 1958; Ismail and El-Nahta, 1964; Ismail and El-Demerdash, 2003), buffalo's milk (Abd El-Tawab *et al.*, 1988a; Awad *et al.*, 2015; Hamad, 2001; Hussein and Shalaby, 2014; Ismail and El-Nahta, 1964; Ismail and El-Demerdash, 2003; Sameh, 2016; Wahba and El-Abbassy, 1982a, 1982b, 1982c), goat's milk (Ismail and El-Demerdash, 2003), and sheep's milk (Ismail and El-Demerdash, 2003).

Manufacturing of Karish cheese

Traditional manufacturing process

Karish cheese is made traditionally by leaving the raw milk in earthenware pots for 24-36 h during the summer season and 48-72 h during the winter season to produce the cream layer on the surface. The milk is coagulated by the natural microflora (Laban Rayeb). Then the cream layer is removed. The curd is poured into a mat for 2-3 days to drain the whey and obtain the desired texture of Karish cheese.

Then the salt is added, and cheese is cut into cubes and left for a couple of hours to drain the whey (Phelan *et al.*, 1993). Karish cheese can be consumed as fresh cheese within 1-2 weeks shelf-life, or it can be pickled in Ballas (Figure 4) for more than a year (Abou-Donia, 1984, 1986; El-Gendy, 1983; Fox, 1993; Moustafa, 1967). The quantity of Karish cheese produced in Egypt is unknown; however, approximately 50% of the total produced milk in Egypt is employed for the manufacturing of Karish cheese (Moustafa, 1967).

Large-scale manufacturing process

Karish cheese is recently made in large scale factories. Cheesecloth was used for whey drainage instead of using the Shenda in the traditional method. The effects of different heat treatments were studied to maintain and standardize the flavor and the properties of Karish cheese. Pasteurized skim milk has been utilized in Karish cheese manufacture (Abdou and Dawood, 1977; Abou-Dawood and Gomai, 1977; Abou El Ella and Farahat, 1979; El-Sadek and Abd-El-Motteleb, 1958). In addition to pasteurization, adding starter cultures before manufacturing was studied to keep the typical flavor of Karish cheese. Many researchers have used single starters of lactococci, such as *Lactococcus lactis* subsp *lactis* and *Lactococcus lactis* subsp *cremoris* (El-Zayat and Omar, 1987) or yogurt starters which contained *Lactobacillus delbrueckii* subsp *bulgaricus* and *Streptococcus salivarius* subsp *thermophilus* (El-Alamy, 1984; El-Shibiny *et al.*, 1984) (Fig. 7). The best flavor was obtained in the Karish cheese, which was manufactured from Laban Rayeb, followed by the buttermilk and then skim milk (El-Gendy, 1983). This good flavor in Karish cheese made from Laban Rayeb is due to the favorable fermentation by natural microflora, which occurs in Laban Rayeb compared to the other two products.

The composition of Karish cheese

The chemical composition of Karish cheese made from cow's milk, buffalo's milk, goat's milk, and sheep's milk is shown in Figure 6. The moisture content of fresh Karish cheese ranged from 69 to 77 % (Ismail and El-Demerdash, 2003), and decreased during the ripening period. However, fat, protein, and salt contents increased with increasing the dry matter in the Karish cheese during storage (Abou-Dawood and Gomai, 1977; El-Sadek and Abd-El-Motteleb, 1958; El-Sadek and Motteleb, 1958; Ismail and El-Demerdash, 2003). The pH of Karish cheese decreased from 5.2 to 3.9 during the 3 months of ripening (Abou-Dawood and Gomai, 1977). The pH of Karish cheese varied depending on the coagulants used in the manufacturing and type of starter cultures. The calcium and phosphorus contents of Karish cheese immediately after manufacturing were 1.8% and 1.6%, respectively (Abd El-Tawab *et al.*, 1988b). The composition of Karish cheese varied within cheese samples, depending on the milk cheese type. Using skim milk in making Karish cheese resulted in manufacturing low-fat Karish cheese compared to utilizing whole milk (El-Sadek and Abd-El-Motteleb, 1958; El-Sadek and Motteleb, 1958; Ismail and El-Nahta, 1964).

Mish cheese

Mish cheese is a traditional dairy product (Figure 5) consumed by Egyptian farmers in rural areas and usually utilized as an appetizer (El-Gendy, 1983). Mish cheese is made by storing the Karish cheese in earthenware jars called Zallaa or Ballas (Figure 4) for more than one year for pickling and ripening. Mish cheese is a yellowish-brown cheese and has a sharp flavor with high salt content (El-Gendy, 1983). Mish cheese is mainly made from Karish cheese in the rural areas, while some wealthy farmers manufacture Mish cheese from whole milk with adding Ras cheese to it.

The ancient Egyptians have consumed a similar type of Mish cheese (Engelbach, 1961). The composition of Mish cheese (Figure 9) was investigated in many studies (Abou-Donia and El-Soda, 1986; A. F. El-Erian *et al.*, 1975; El-Gazzar and Monib, 1976; El-Zayat and El-Safty, 1985; Nassib and El-Gendy, 1974; Zaki and Shokry, 1988). It has been reported that Mish cheese had 4 groups of bacteria; Micrococci (60%), bacilli (20%), *Arthrobacter* (18%) and anaerobic sporeformers (2%) as shown in Figure 6 and the total aerobic bacterial count differed between samples (A. F. M. El-Erian *et al.*, 1975).

Manufacturing of Mish cheese

The manufacturing process of Mish cheese has been described by many researchers (Abou-Donia, 1996; Abou-Donia and El-Soda, 1986; A. F. El-Erian *et al.*, 1975; El-Gendy, 1983; Hamdy and Taha, 1954). The process of making Mish cheese is different among areas in the same country; however, the principles steps are similar (Hamdy and Taha, 1954).

Mish cheese, which is obtained from Karish cheese, has a high content of moisture, so more water is removed from the Karish cheese before pickling. Therefore, Karish cheese is left after being manufactured in a dry place for several days (El-Gendy, 1983). The Karish cheese is then packed in layers in the Ballas (Figure 4), and salt is sprinkled on each layer. Then the container is filled with the pickling medium, which contains; buttermilk, Laban Rayeb, whey, and Mourta. Mourta is the residue ingredient after butter oil (Samna) manufacturing and consists of protein, fat, water, and salts. After adding the pickling medium into the Zalla or Ballas, some additives are added, such as spices (ground black pepper, cumin, and sharp-flavored red pepper), annatto, 6-15% salt, green pepper, and some old Mish as a natural

starter (El-Gendy, 1983). El-Gendy (1983) reported that borax salts, such as sodium borate, could be added at the top of the Ballas as well as sharp red pepper and some spices tied in cheesecloth to kill *Pyophilla casei* larvae which contaminate the cheese during manufacturing. The Ballas is sealed with mud to provide anaerobic conditions and stored at room temperature for at least one year. Old-Mish cheese has a distinct sharp flavor similar to Roquefort or Romano cheese (Hamdy and Taha, 1954).

The composition of Mish cheese

The composition of Mish cheese is shown in Figure 9. The moisture, fat, protein, and salt contents of Mish cheese ranged from 43.00 to 76.00 %, 0.07 to 11.00 %, 9.50 to 14.00 %, and 9.40 to 12.90 %, respectively (Figure 9). The differences in Mish cheese composition could result from the differences in the composition of Karish cheese, composition of milk, composition of pickling solution, natural starter source, the amount of salt and different additives, ripening longevity, and the storage temperature. The calcium and phosphorus contents ranged from 0.36 to 0.39% and 0.32 to 0.39%, respectively, in Mish cheese (Zaki and Shokry, 1988). The sodium chloride in Mich cheese is ranged from 9-13%, as shown in Figure 9, whereas the potassium is 0.19% (Zaki and Shokry, 1988).

Ras cheese

Ras cheese is known in Egypt and Arab countries as Roumy cheese, and it is one of the leading traditional hard cheese in Egypt and Mediterranean countries (Hofi *et al.*, 1970). It resembles the Greek Kefalotyri cheese, both originally being manufactured from goat's or cow's milk. It is manufactured under artisan conditions from cow's, buffalo's milk, or a mixture of both and consumed after

3 months of ripening when the pungent and sharp flavor is developed in the cheese (Hammam *et al.*, 2018; Hofi *et al.*, 1970; Phelan *et al.*, 1993). Traditionally, Roumy cheese is manufactured from raw milk (Ayad *et al.*, 2004; Hammam *et al.*, 2018; Hofi *et al.*, 1970). Raw Roumy cheese showed high and acceptable flavors than pasteurized Roumy cheese due to the favorable fermentations that occur by the natural microflora in raw milk (Hammam *et al.*, 2018; Hofi *et al.*, 1970); however, flavors and composition had wide variations due to utilizing raw milk (AWAD, 2006).

According to the recent trend, all dairy products are supposed to be produced from pasteurized milk, so the Egyptian standards specify that Ras or Roumy cheese should be made from pasteurized milk and should contain not less than 60% solids and 45% fat in solids, and the final product must be free from pathogenic microorganisms. Roumy cheese has been examined by many researchers using different heat treatments and different starter cultures for manufacturing Roumy cheese with the typical flavor of Roumy cheese made from raw milk (Awad, 2006; Awad *et al.*, 2007; Ayad *et al.*, 2004; El-Neshawy, 1984; Hammam *et al.*, 2018; Hofi *et al.*, 1970; Kebary *et al.*, 1999; Omar and Ashour, 1982).

Manufacturing of Ras cheese

The traditional method of making Ras or Roumy cheese

Raw milk is warmed at 32 °C in a cheese vat, and then rennet is added (6%) into the milk. The milk is coagulated in approximately 45 min at 32 °C. The curd is cut vertically and horizontally using 0.5-inch knives. Then the temperature is increased from 32 °C to 45 °C while the curd is stirred until the acidity reaches 0.14% (Hammam *et al.*, 2018; Hofi *et*

al., 1970). Two third of the whey is drained, and then 1.5% of salt is added and left for 15 min before drainage the rest of the whey. Then the cheese is pressed overnight, and salt is sprinkled again on the surface of cheese for one week before being coated with a plastic wax or sealed under vaccum (Hammam *et al.*, 2018; Hofi *et al.*, 1970).

Making Ras or Roumy cheese from pasteurized milk

Making Roumy cheese from pasteurized milk

is similar to the traditional method. However, the milk is first pasteurized and cooled to 32 °C before adding the starter cultures. The starter culture is a mixture of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* with a ratio of 1:1. The rennet is added as described by Hofi *et al.*, (1970) and Hammam *et al.*, (2018) when the acidity increases to 0.19%. The milk is coagulated in 45 min and then cut, heated, salted, and pressed as described in the traditional method.

Figure.1 Flowchart of the cheese production process in the plant

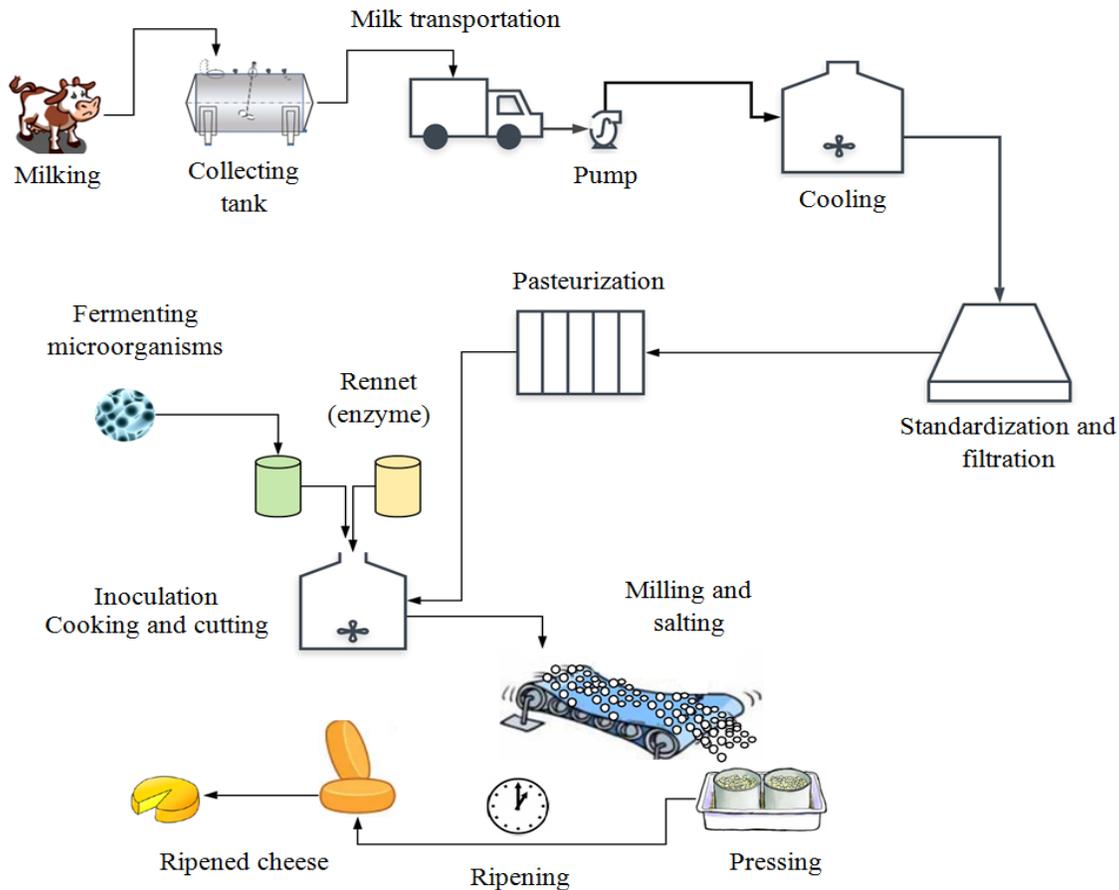


Figure.2 The Domiati cheese composition obtained from several varieties of milk during ripening

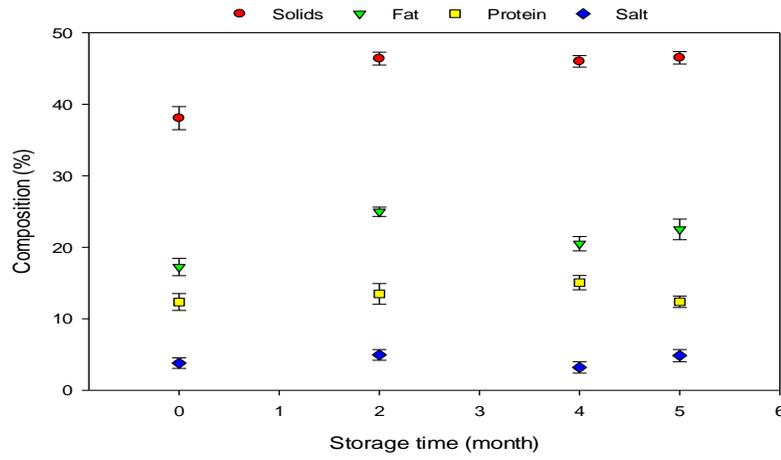


Figure.3 Matrad or Shalia used for raw milk fermentation to manufacture Karish cheese or Laban

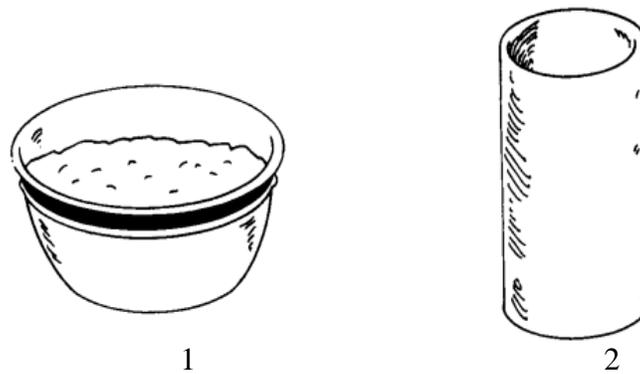


Figure.4 Mat or Shenda (a type of reed) used to drain Karish cheese curd from the whey

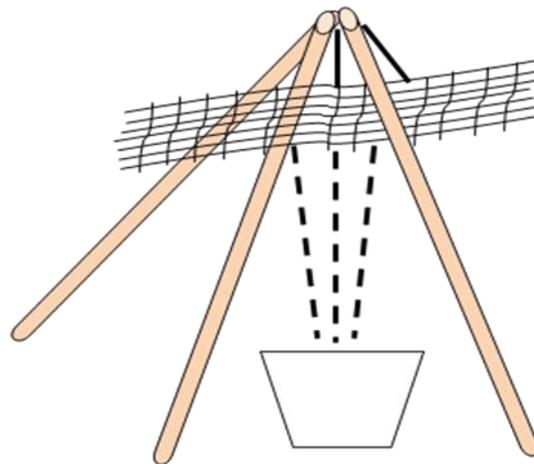


Figure.5 Different shapes of Ballas or Zalla used for ripening and storage Mish cheese. Adopted from (a) Ahmed (2018); (b) Atom (2014); and (c) El-Gendy (1983)

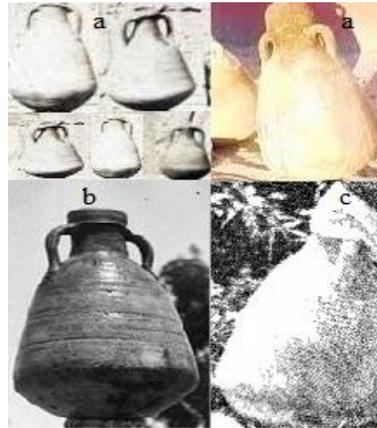


Figure.6 The Karish cheese composition made from several varieties of milk

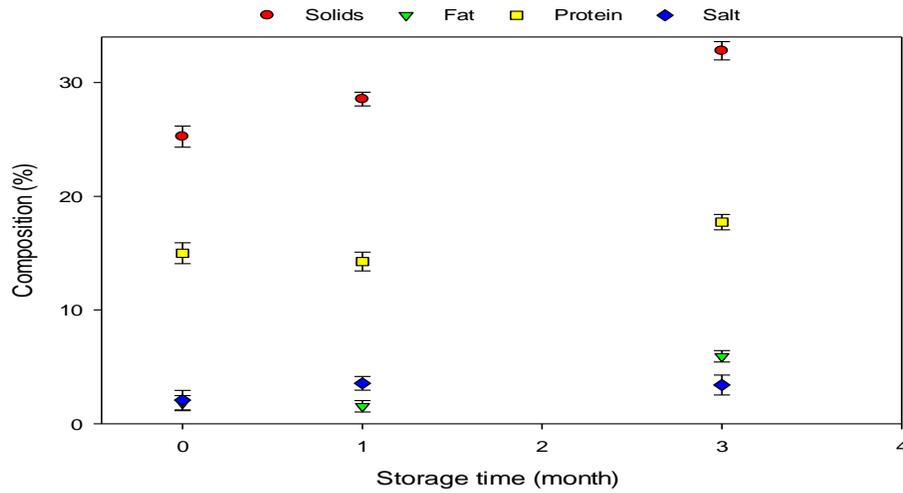


Figure.7 Ripened Mish cheese. Adopted from Mlakaty (2013)



Figure.8 The percentage of microbial flora content in Mish cheese. Adopted from (El-Erian and El-Gendy, 1975)

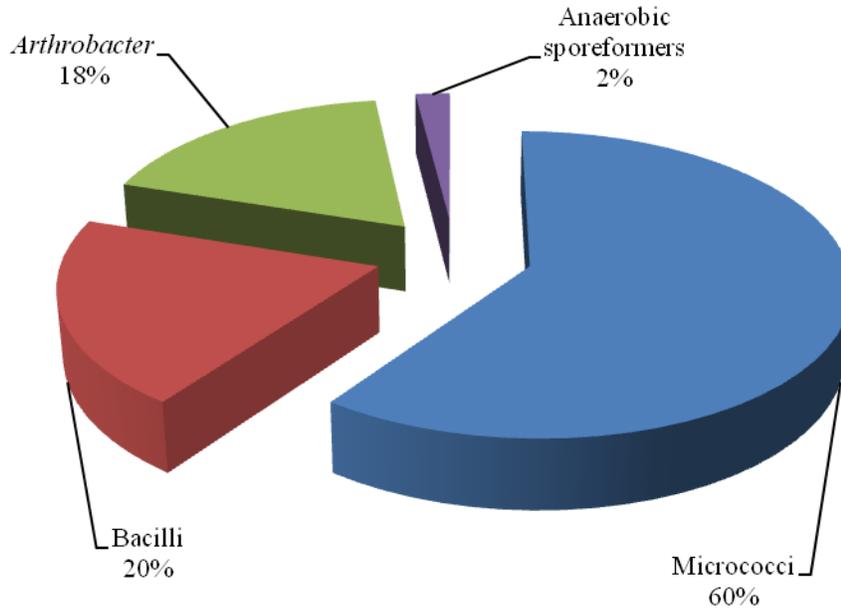


Figure.9 The chemical composition of Mish cheese

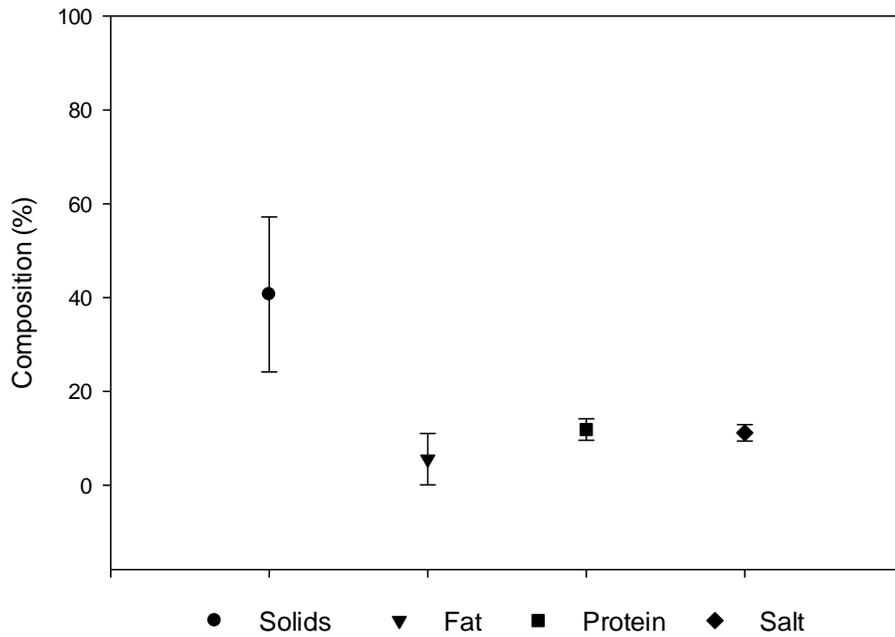
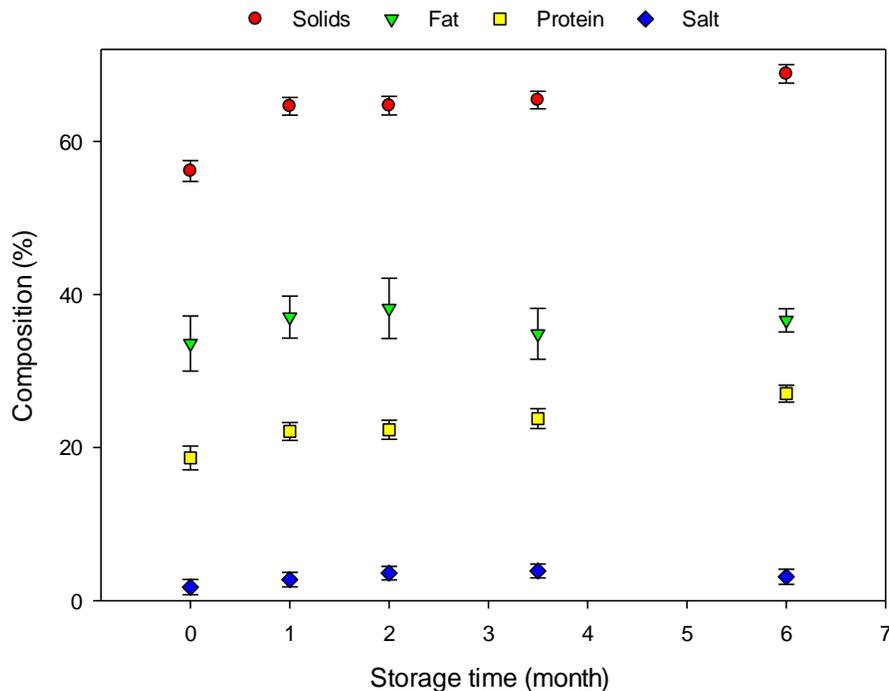


Figure.10 The composition of Ras cheese during ripening



The composition of Ras cheese

Figure 10 is shown the composition of Roumy cheese. The moisture content in fresh Roumy cheese is approximately 40% (AWAD, 2006; El-Neshawy, 1984; Hofi *et al.*, 1970) and can reach up to 47-49% (Awad *et al.*, 2007; Hammam *et al.*, 2018; Kebary *et al.*, 1999; Omar and Ashour, 1982) depending on the milk types and the processing method. The moisture content of Roumy cheese decreases during the ripening period (AWAD, 2006; Awad *et al.*, 2007; El-Neshawy, 1984; Hammam *et al.*, 2018; Hofi *et al.*, 1970; Kebary *et al.*, 1999; Omar and Ashour, 1982) and thereby increasing the fat, protein, and salt contents as a result of increasing the solids. The Roumy cheese that obtained from a mix of cow's milk and buffalo's milk (1:1) after 6 months of ripening had approximately 30%, 39%, 27 and 2 % of moisture, fat, protein and salt, respectively (Hofi *et al.*, 1970), while Roumy cheese made from a mixture of cow's milk and buffalo's milk (4:1) after 6 months of ripening had around

32%, 34%, 27 and 4 % of moisture, fat, protein and salt, respectively (AWAD, 2006). The composition of Roumy cheese varies based on the type of milk used in cheese manufacture, additives, and starter cultures.

The health benefits of cheese

Cheese is an essential food for maintaining healthy bone growth in children and young people. It is a rich dietary source of calcium, protein, magnesium, zinc, and vitamins A and D, so it positively influences bone health from osteoporosis (Bonjour *et al.*, 2012). Also, calcium plays a vital role in the formation of teeth, and cheese is a good source of calcium. Also, a study showed that consumption of cheese provides protection against tooth decay (Adegboye *et al.*, 2012). Additionally, some cheeses, especially white cheeses made from cow's milk, are found to be rich in omega-3 fatty acids that benefit the cardiovascular system and brain (Sofi *et al.*, 2010).

In conclusion, cheese is a dairy product that considers essential daily food for many people around the world. Cheese has shelf-life longer than milk. It has a nutritional value that provides an essential source of digestible protein and minerals, including calcium and phosphorus. Cheese is a dairy food essential for building healthy bones and teeth. There are several soft and hard cheese varieties in Egypt made from cow's, buffalo's, camel's, goat's, and sheep's milk. This review discussed the technological and chemical properties of the most popular soft and hard cheeses and their health benefits in Egypt and other countries.

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