ACTA Acta Sci. Pol. Technol. Aliment. 17(2) 2018, 107–116
www.food.actapol.net pISSN 1644-0730 eISSN 1898-9594 http://dx.doi.org/10.17306/J.AFS.2018.0550

REVIEW PAPER

Received: 28.01.2018
Accepted: 3.04.2018

CARRAGEENAN AS A FUNCTIONAL ADDITIVE IN THE PRODUCTION OF CHEESE AND CHEESE-LIKE PRODUCTS

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ABSTRACT

Carrageenan is a well-known gelling agent used in the food industry. The present review of patent and scientific literature shows that carrageenan is a useful additive in the cheese production process. The gel-strengthening properties of carrageenan are as a result of the fairly strong bonds it forms with casein macromolecules. However, carrageenan-casein interaction is dependent on pH. Different carrageenan types have different charge levels (the most charged is the helix form of lambda-carrageenan), which affects the carrageenan-casein aggregates. The correct concentration of carrageenan and temperature treatment can improve cheese yield and whey protein recovery, which is desirable for cheese producers. Even small amounts of this hydrocolloid can increase cheese firmness and maintain cheese structure after cheese curd heating. Carrageenan improves cheese structure and other properties, such as ease of grating or slicing, which are very important for customers. Some modifications to cheese composition can destroy the natural cheese structure, but the addition of carrageenan can be useful for creating modified cheese-like products with desirable attributes. Carrageenan can be a good replacement for emulsifying salts, to stabilize cheese fat without disturbing the Ca:P ratio. The replacement of emulsifying salts with carrageenan (as little as 1%) results in a homogenous cheese product. For that reason, carrageenan is a useful additive for maintaining the organoleptic and structural values of fat-free cheese. Carrageenan can also stabilize the structure in cheese-like products and replace casein in cheese imitations.

Keywords: carrageenan, cheese technology, rheology, texture, functional properties, whey protein

INTRODUCTION

Polysaccharides are well known as functional food additives used to improve the texture of final products (Franck, 2006; Rayner et al., 2016). One well-known example is agar, which is used in confectionary, bakery and dairy products, ice creams and other foods (Piculell, 2006). Some hydrocolloids also improve the nutritional values of foods. The most widely known example is the probiotic polysaccharide inulin, which is added to baked goods, meat, dairy products, frozen desserts etc. (Franck, 2006).

Polysaccharides are obtained mainly from plants and microorganisms. Among seaweed-sourced polysaccharides, the most well-known is carrageenan. Carrageenan is a typical ingredient in sauces and salad dressings (Milani and Maleki, 2012; Piculell, 2006). Carrageenan is also used as a gelling agent in meat products, sausages and even canned pet food. The carrageenan market is the fourth largest global hydrocolloid market and the largest seaweed-derived market. Its global production is estimated to be in the range from

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about 70,000 MT $year^{-1}$ to over 110,000 MT $year^{-1}$. Carrageenan production takes place mainly in the Asia-Pacific region (45% of total global production), whereas production in Europe and America is estimated to be about 12% and 17% respectively (Campbell and Hotchkiss, 2017).

Carrageenan is often used in the dairy industry due to its ability to interact with casein (Piculell, 2006). It is added to frozen desserts, yoghurts, milk drinks, whipped and coffee creams etc. (Piculell, 2006; Rayner et al., 2016). Despite the utilization of carrageenan in a wide range of dairy products, there is little information about the use of carrageenan in cheese-making. The present review of scientific and patent literature shows that the addition of carrageenan can improve cheese texture, mouthfeel and other quality attributes.

CARRAGEENAN STRUCTURE AND GEL-FORMING PROPERTIES

Carrageenan has been used as a food additive for around a hundred years. Carrageenan is the generic name for a family of gel-forming linear sulfated polysaccharides extracted from certain species of red seaweeds (*Rhodophyceae*; Bourriot et al., 1999; Černíková et al., 2008; Langendorff et al., 1999). This plant is harvested mainly on the rocky Atlantic coast of North America and Europe. According to the European Parliament and Council Directive No 1333/2008, carrageenan is marked as E-407 or E-407a. In general, carrageenan belongs to the group of food additives know as hydrocolloids. Carrageenan is used in food technology mainly as a stabilizing and gelling agent (Bourriot et al., 1999; Černíková et al., 2010). The main products containing carrageenan are jellies, cured and canned meat, yoghurt and coffee cream.

There are three main commercial types of carrageenan (κ – kappa-, ι – iota-, λ – lambda-carrageenan). All types of carrageenan contain repeating units of D-galactose and 3,6-anhydrogalactose. The monomer units are bonded by alternating α-1,3 and β-1,4 glycosidic linkages (Černíková et al., 2008). The main differences in the structures of different carrageenan types are the number and position of ester sulphate groups on the galactose monomer units. The number of ester sulphate groups has an effect on carrageenan solubility. A higher level of sulphate groups results in a lower solubility temperature. All types are soluble in hot water, but only lambda-carrageenan is soluble in cold water. Sodium salts of all the three types are very soluble (Černíková et al., 2008; Langendorff et al., 2000).

In aqueous solutions, carrageenan macromolecules form flexible curls and helical structures which have the ability to form gels (Bourriot et al., 1999; Langendorff et al., 1999). Iota and kappa-carrageenan are known to undergo temperature-dependent transitions from a coil conformation to a helix. Transition temperatures are ca. 47°C for iota-carrageenan and 37°C for kappa-carrageenan. The conformation transition also depends on the ionic environment (Langendorff et al., 2000; Piculell, 2006; Rees et al., 1969).

CARRAGEENAN AS A COAGULANT AT CURD FORMATION STAGE

Cheese is produced from milk by the coagulation of milk proteins, the separation of solid curd (which contains fat and proteins) from liquid whey and finally the formation of the final product by pressing. General differences between types of cheeses are sensory traits and textural properties. The attributes of different cheeses are determined by the manufacturing technology employed. Ionic gums, including carrageenan, are common additives at the stage of milk coagulation. The gums are added before fermentation, in order to boost the formation of curds (Cha et al., 2004). The underlying mechanism is electrostatic interaction between positively charged milk proteins and negatively charged polysaccharides. It is worth noting that the facilitation of cheese formation requires the appropriate carrageenan concentration, pH and heat treatment schedule (Dybing and Smith, 1998).

Carrageenan, mainly kappa-carrageenan, is well known for coagulating whey proteins (Dybing and Smith, 1998). According Makhal et al. (2013), carrageenan added in as low concentrations as 0.005% and 0.015% resulted in a curd yield of 13.3% to 13.8%, a significant increase in comparison to a control sample with a curd yield of 12.2%. An increase in moisture retention from 74.4% (control sample) to 74.9% (0.005% carrageenan concentration) and 75.4% (0.015% carrageenan concentration) was also observed. The total protein content increased from 73.4% in the control sample to 88.3% in the sample with 0.005% carrageenan concentration. Whey protein recovery showed the highest increase, from 1.2% in the control sample to 14.5% in the sample with 0.005% carrageenan concentration. Increasing the proportion of carrageenan to 0.025% did not result in any additional increase in curd yield, or improvement of cheese attributes. The increased recovery of whey protein and total protein content was attributed to the possible interaction between whey proteins and kappa-carrageenan, which caused the whey proteins to coagulate. Protein isolates in the pH range 3–7 typically form weak gels only after heating. However, with the a 1% addition of kappa-carrageenan (0.5%), whey protein can form a gel after reaching pH ca. 6. Acidification results in the strengthening of the formed gel. Conversely, gel formed by whey protein isolate and kappa-carrageenan was weakened after heat treatment at 80°C for 30 min. Weakening also occurred when whey protein isolate was preheated (to 80°C for 30 min) before the addition of kappa-carrageenan. It was inferred that kappa-carrageenan in combination with whey protein isolate may be used in dairy products in which minimal thermal treatment is applied (Mounsey, 2008). The balance between calcium and potassium ions is important for the results of carrageenan addition. The amount of calcium ions is typically about 10 times higher than the amount of potassium ions (Fox et al., 2017). Disturbing the calcium to potassium ion balance may result in a decrease in cheese gel rigidity (MacArtain et al., 2003; Spagnuolo et al., 2005).

CARRAGEENAN AS A MODIFIER OF CHEESE FIRMNESS AND SLICING ABILITY

Carrageenan is known to effect the rheological characteristics of cheese. The addition of carrageenan (mainly kappa-carrageenan) can boost the slicing and grating ability of processed cheese (Imeson, 2000). Carrageenan was reported to increase the firmness of wheyless cream cheese (Cha et al., 2004). A more recent study (Černíková, et al., 2008) showed that increasing the concentration of κ-carrageenan and ι-carrageenan results in enhanced rigidity of the processed Eidamsky Blok-Dutch type cheese. Processed cheese with added carrageenan was found to be very hard and impossible to spread (Černíková et al., 2010). Panela-type cheese with added carrageenan was also harder than a control sample (Rojas-Nery et al., 2015).

So far, the effect of carrageenan on the rheology of cheese has not been studied in its entirety. Many scientists have tried to explain the differences observed upon addition of different kinds of carrageenan, primarily the fact that the addition of ι-carrageenan creates firmer gels than the addition of κ-carrageenan. Higher concentrations of carrageenan promote interactions between their chains, which allows a more rigid structure to be formed (Černíková, et al., 2008; Ribeiro et al., 2004). Probably, a certain minimal concentration exists which allows a suitable network between carrageenan chains to be created. Higher carrageenan concentrations result in increased gel strength and hardness. The addition of κ-carrageenan and ι-carrageenan in amounts of 0.15% and 0.25% w/w results in increased rigidity of processed Eidamsky Blok-Dutch type cheese with different amount of fat (Černíková, et al., 2008). The addition of 0.05% of ι-carrageenan gives a harder gel than the same amount of κ-carrageenan. The same effect is observed at increased concentrations of carrageenan (Černíková et al., 2008). The addition of carrageenan can compensate for the effects of inadequate heat treatment of curds. The texture of cottage cheese with added kappa-carrageenan remained unaffected after heat treatment of the curd at 90°C for 5 min. The most probable explanation is that kappa-carrageenan interacts with milk proteins, resulting in the strengthening of the cheese gel (Makhal et al., 2013).

CARRAGEENAN AS A FAT EMULSIFIER

The usual components in cheese production are phosphate- and citrate-based emulsifying salts. Unfortunately, the addition of phosphate-based salts destroys the optimal molar ratio of Ca:P which, should be around 1:1 (Palacios, 2006). A higher amount of phosphorus changes the Ca:P ratio to 1:1.5–3.0, which may lead to diseases such as osteoporosis. The cause of this is the detrimental impact of excess phosphorus on bone structure (Schäffer et al., 1999). Scientists have looked for phosphate substitutes which can form strong bonds with milk proteins and will not have negative effects on human health. Some reports have suggested the addition of vegetable hydrocolloids to replace phosphate salts. (Schäffer et al., 1999; 2001). Carrageenan addition is useful to maintain a favorable ratio of inorganic ions in cheese raw materials (Bourriot et al., 1999; Černíková, et al., 2008). Several hydrocolloids were examined as possible replacements for phosphate salts (Černíková et al., 2010). Both κ-carrageenan and ι-carrageenan were found to stabilize fat globules in processed cheese. The carrageenan concentration required is near to 1%. Processed Edam cheese with a lower amount of carrageenan (0.1–0.3% of ι-carrageenan and 0.1–0.4% of κ-carrageenan) was evaluated as slightly inhomogeneous, with a more fluid upper layer slightly separated from the lower layer. Both layers contained similar amounts of fat globules, but the average size of the fat globules was less in the lower layer compared to the upper layer. A carrageenan concentration of 0.5–1% helps to maintain homogeneity of the final product without significant release of fat. The average size and number of fat globules were different in different samples at carrageenan concentrations below 1%. Samples with 1% of κ-carrageenan have a similar number and size of fat globules. The results of dynamic oscillatory rheometry also show that the complex shear modulus was nearly the same. In the sample considered to be homogenous, the process of gel formation was observed while cooling from 80°C to 10°C. Gel formation with the addition of traditional emulsifying salts was different from that with the addition of carrageenan. Increased complex shear modulus was observed in the sample with the addition of both carrageenan and emulsifying salts. However, this boost was not as high as that observed in the sample with carrageenan and without emulsifying salts. For the sample with carrageenan, the highest growth in complex shear modulus was observed at temperatures from 55 to 45ºC, near to the temperature of coil-to-helix transition. The inference was that carrageenan is a promising substitute for emulsifying salts (Lynch and Mulvihill, 1996). Almost identical results were obtained by Shabbir et al. (2016) when emulsifying salts were replaced by different concentrations of kappa-carrageenan in processed cheddar cheese. Samples were analyzed for physicochemical and sensory attributes during storage for 45 and 90 days. The final product was harder and less able to melt with increasing carrageenan concentration; only the products with 0.15% carrageenan concentration and 2% emulsifying salts possessed the best physicochemical and sensory attributes. There was a hypothesis that the ability of carrageenan to stabilize fat is related to binding hydrophobic parts of protein in the presence of calcium ions (Lynch and Mulvihill, 1996).

APPLICATION OF CARRAGEENAN IN LOW-FAT CHEESE

Low-fat cheese is a healthy product which can be a good substitute for normal cheese in a reduced-fat diet. After reducing the amount of milk fats in low-fat cheese, it may be required to add some substances to maintain the expected consistency and structure of the final product. The addition of some hydrocolloids, mainly carrageenan, may replace the addition of fat and emulsifying salts. This is a result of the ability of carrageenan to stabilize the consistency and textural properties of cheese products. Carrageenan is known as an ingredient in fat-free cream cheese (Crane et al., 1993). Emulsified soybean oil with added soy protein isolate and carrageenan can help to obtain panel-type cheese (Rojas-Nery et al., 2015). Replacing milk fat with emulsified soybean oil resulted in higher cheese yields and moisture content, as well as in decreased amounts of fat (Table 1). Of the three carrageenan types used, and the three substitution levels (25%, 50% and 75%), the best results were achieved in samples containing lambda-carrageenan and milk fat substituted at 75% (Table 1). Total protein content was maintained in the range of 11.83% (iota-carrageenan – fat substitution of 50%) to 14.11% (iota-carrageenan – fat substitution of 75%), compared with a control with a protein content of 12.41%. The main effect of replacing milk fats with carrageenan was increased water retention in the coagulated cheese curd, which resulted in higher yield (Rojas-Nery et al., 2015). Emulsified soybean oil droplets are larger than those of milk fat, resulting in increased openness of the cheese matrix and larger interstitial spaces (Giroux et al., 2013; Rojas-Nery et al., 2015).

Substitution of milk fat also results in an increase in cheese hardness, with significant differences between samples containing kappa and iota-carrageenan. The addition of kappa-carrageenan results in increased adhesiveness of panela-type cheese, unlike the addition of lambda-carrageenan (Table 2). It is important

Table 1. Physicochemical properties of fat-reduced panela-type cheese employing emulsified oil with carrageenans, % (Rojas-Nery et al., 2015)

Carrageenan type in emulsified soybean oil/soy protein isolate	Milk fat substitution	Yield	Moisture	Fat
Control	0	16.41^{d,C} ±0.00	56.84^{c,C} ±2.03	30.40^{a,A} ±0.21
Iota	25	17.18^{c,B} ±0.00	57.88^{b,B} ±2.51	27.00^{b,B} ±1.20
	50	17.47^{b,B} ±0.17	58.71^{a,B} ±2.25	26.50^{c,B} ±0.60
	75	17.60^{a,B} ±0.00	58.92^{a,B} ±1.91	25.50^{d,B} ±0.25
Kappa	25	15.50^{c,B} ±0.00	58.74^{b,B} ±1.95	27.20^{b,B} ±0.10
	50	15.40^{b,B} ±0.00	59.14^{a,B} ±2.03	26.80^{c,B} ±0.30
	75	16.22^{a,B} ±0.00	59.81^{a,B} ±2.38	25.64^{d,B} ±0.30
Lambda	25	16.41^{c,A} ±0.00	59.62^{b,A} ±2.52	26.90^{b,C} ±1.20
	50	17.70^{b,A} ±0.00	60.40^{a,A} ±2.12	25.85^{c,C} ±1.73
	75	19.08^{a,A} ±0.00	60.72^{a,A} ±1.71	25.18^{d,C} ±0.30

$^{a–d}$Means that data with the same letter in the same column are not significantly ($p > 0.05$) different for the percentage milk fat substitution.
$^{A–D}$Means that data with the same letter in the same column are not significantly ($p > 0.05$) different for the carrageenan type.

Table 2. Texture analysis of fat-reduced panela-type cheese employing emulsified oil with carrageenans (Rojas-Nery et al., 2015)

Carrageenan type in emulsified soybean oil/soy protein isolate	Milk fat substitution %	Hardness, N	Adhesiveness, N
Control	0	31.40^{b,C} ±0.82	0.75^{a,B} ±0.40
Iota	25	45.19^{a,A} ±3.83	0.70^{a,A} ±0.10
	50	45.81^{a,A} ±8.43	0.75^{a,A} ±0.13
	75	27.87^{b,A} ±4.50	0.74^{a,A} ±0.77
Kappa	25	41.13^{a,A} ±2.17	0.80^{a,A} ±0.17
	50	29.30^{a,A} ±1.52	0.79^{a,A} ±0.16
	75	39.25^{b,A} ±2.93	0.76^{a,A} ±0.17
Lambda	25	27.80^{a,B} ±1.21	0.66^{a,C} ±0.08
	50	39.63^{a,B} ±0.89	0.67^{a,C} ±0.05
	75	32.16^{b,B} ±2.27	0.70^{a,C} ±0.05

$^{a–d}$Means that data with the same letter in the same column are not significantly ($p > 0.05$) different for the percentage of milk fat substitution.
$^{A–D}$Means that data with the same letter in the same column are not significantly ($p > 0.05$) different for the carrageenan type.

that replacing milk fat results in a decrease in elasticity-related textural parameters. Cohesiveness (dimensionless) was significantly lower in samples with kappa-carrageenan – from 0.34 to 0.26, compared to a control sample with a cohesiveness of 0.39. Both resilience and springiness of cheese decrease when carrageenan is added and fat is removed. The resilience values decreased to 0.67 and 0.59 for iota and kappa-carrageenan respectively, compared to 0.76 for the control sample. The springiness values (dimensionless) were registered in the range of 0.77 to 0.75 for iota-carrageenan and of 0.76 to 0.75 for kappa-carrageenan, compared to 0.80 for the control sample (Rojas-Nery et al., 2015).

The addition of different types of carrageenan to low-fat Colby cheese resulted in changed rheological properties and nutrient content relative to full-fat cheese. The sample with kappa-carrageenan (0.15 g/kg) had higher protein and moisture contents and lower fat content and moisture in the non-fat substances (MNFS). Samples with iota and lambda-carrageenan had higher moisture content and lower fat content than the control. The highest protein content was found in the sample with kappa-carrageenan. Protein recovery remained almost unchanged. Only protein recovery in cheese with lambda-carrageenan was higher than in the control.

One very important stage of cheese production is ripening, when protein is hydrolyzed to peptides and amino acids by starter bacteria, milk proteases and coagulant enzymes. The degree of proteolysis may be partially attributed to the MNFS level. A high level of proteolysis was observed in cheese with lambda and iota-carrageenan, which also have high MNFS levels. Accordingly, samples with low MNFS also have low levels of proteolysis. Both hardness and springiness values were found to decrease with ripening. The exception was cheese with kappa-carrageenan, for which springiness did not change significantly. The largest decrease in springiness was observed in samples with iota and lambda-carrageenan. The reduction in the fat content affects the cheese texture and rheology. To improve these characteristics, it may be necessary to increase the moisture content in order to provide MNFS at the same or even at a higher level than full-fat cheese. The addition of ι- and λ-carrageenan results in increased moisture content and MNFS level, while decreasing hardness, springiness and storage modulus. Higher levels of MNFS accelerated the release of soluble proteins, further increasing rheological and textural properties (Wang et al., 2016).

Mixed hydrocolloids (kappa-carrageenan, locust bean gum and xanthan gum) proved to be good fat replacements in the production of low-fat Dominati cheese. The blended hydrocolloids provide high water binding capacity and a low rate of moisture loss during cheese ripening. Higher concentrations of fat replacers show higher moisture content. However, a decrease in moisture content was observed in all the samples during the ripening period. Cheese pH also decreased at this stage, although reducing fat has no significant impact on the pH value. Probably, higher acidity is a result of the changed composition of the cheese, because higher moisture content leads to an increase in chemical and biochemical reactions. The addition of hydrocolloids also results in higher yield after ripening due to a lower rate of mass loss. Cheese yield was observed to increase significantly and proportionally relative to the amount of hydrocolloids added. The highest yield was observed in the sample containing the highest concentration of hydrocolloids (0.75 g/kg of milk). Fat in cheese is also important for flavor. The highest sensory analysis score was given to full-fat cheese. Replacing fat with hydrocolloids can improve sensory values and balance the fat reduction defects, achieving a score for low-fat cheese almost equal to that of full-fat cheese (Alnemr et al., 2016).

APPLICATIONS OF CARRAGEENAN IN CHEESE ANALOGUES, CHEESE IMITATIONS AND CHEESE-LIKE PRODUCTS

Cheese analogues (cheese substitutions) are food products made to imitate the taste of dairy cheese intended for different types of customers. For example, cheese analogues for vegans are produced from plant milks. Cheese analogues for pizzerias are especially designed to melt well as a pizza topping. Due to their smooth consistency, cheese-like dairy products can replace traditional cheeses (Jackson et al., 2002). Carrageenan may be used as a functional ingredient in cheese-like products, resulting in an increased body and improved texture. On the other hand, carrageenan may result in decreased melting ability. For that reason, cheese-like products may include trisodium phosphate, disodium phosphate, sodium citrate, sodium aluminum phosphate or sodium metaphosphate. Melting properties are improved by sodium salts (Lazaridis et al., 1980).

Properties of processed cheese analogues with the addition of acidic casein and κ-carrageenan were studied by Sołowiej (2012). Both the additives resulted in increasing product hardness. The addition of κ-carrageenan in low amounts (0.05% and 0.1%) led to a final product with the same or even less hardness than a product with only acidic casein. The samples with 13% casein and 0.3% carrageenan have the highest rigidity. The increased amount of carrageenan results in decreased adhesiveness. Being able to easily remove cheese from its packaging is a very important property for consumers. The addition of carrageenan (0.05% to 0.3%) caused chewiness to increase and meltability to decrease (Sołowiej, 2012).

Mozzarella type cheese analogues are often used as a topping in baked dishes (e.g. pizzas). Mozzarella analogues can lower production costs by replacing expensive ingredients with cheaper substitutes. The addition of hydrocolloids can help to stabilize the final product and achieve desirable characteristics. The sample containing only carrageenan had a firmer structure compared to samples with locust bean gum or xanthan gum. A mozzarella analogue created with two blended stabilizers has desirable softness. Different blends of stabilizers result in different properties. The highest score was reached by xanthan gum blended with locust bean gum. A mixture of carrageenan and locust bean gum also provides good properties (Jana et al., 2010).

One more cheese analogue is tofu, which is soya protein product. Tofu can be a good substitute for traditional cheese in the diets of people who are sensitive to lactose, cholesterol and other substances contained in animal products. Carrageenan may be used as a functional additive in the tofu production process. Carrageenan mixed with coagulants like glucono--delta-lactose and calcium chloride can increase tofu yield, lightness, softness and flexibility. Tofu samples with carrageenan have increased freshness and moisture content. The best results were observed in tofu containing glucono-delta-lactose and 0.1% of carrageenan (Esparan et al., 2011).

The addition of carrageenan also has an influence on the viscoelastic properties of processed cheese analogues made with vegetable fats (Hanakova et al., 2013). Different values of rigidity were registered for different blends of hydrocolloids and fats. Regardless of the hydrocolloid applied, the highest values of rigidity modulus were observed in the sample with coconut fat, followed by the sample with butter, and the lowest was observed in the sample with palm oil. The hardness of the final product increased significantly after the addition of hydrocolloids, but still the highest hardness was observed in the product with coconut fat, followed by the product with butter. The cheese analogue with kappa-carrageenan was the product with highest hardness. This effect may be explained by the interaction of carrageenan and casein. Differences in values of G modulus and melting temperatures of kappa and iota-carrageenan may be explained taking into consideration the coil-to-helix transition temperature. The inference was that the addition of kappa carrageenan to processed cheese analogues can help to create a product with the desired viscoelastic properties and hardness (Hanakova et al., 2013).

Cheese imitations contain both milk casein and vegetable oils. Cheese imitations have nearly the same nutritional values as real cheese, but have a longer shelf life and are cheaper to produce. Carrageenan may be used alongside gelatin as a casein replacement for cheese imitations. Gelatin adds a yellow tint to the casein replacement composition, which is not desirable for cheeses which are normally white, such as mozzarella. For that reason, the amount of gelatin can be decreased and replaced by carrageenan. The addition of carrageenan also improves the texture of the final product (Yoder et al., 1995).

Carrageenan may be also used in the production of cheese sauce. Carrageenan applied in the correct ratio with other vegetable gums and hydrocolloids results in a homogenous sauce with extraordinary mouthfeel (Spanier et al., 1986). In order to meet customer expectations, some companies also offer dairy products with decreased protein. The production of cream cheese compositions with lower protein contents requires the addition of texture stabilizers. Carrageenan proved to be a good additive to these kinds of products due to its ability to stabilize dairy components (Laye et al., 2005).

CARRAGEENAN AS A COMPONENT OF CHEESE COATING

Carrageenan can be also used as a component of coating material for cheese (Kampf and Nussinovitch, 2000). Cheese samples with hydrocolloid coatings have increased gloss, which is desirable in marketing. The highest gloss was observed for samples with carrageenan and gellan. Bubbles trapped in the carrageenan coating can be the result of ripening. Carrageenan coatings do not change the taste of the cheese and adhere well to the cheese surface after 144 h. The coated cheese samples have an extended shelf life, reduced mass loss and lower changes in pH under storage (Kampf and Nussinovitch, 2000).

CONCLUSION

The application of carrageenan as an additive in cheese making results in increased curd yield and whey protein recovery, as well as improved cheese structure. Moreover, the addition of carrageenan enables cheese structure to be maintained after thermal treatment of the curd in cottage cheese production. The addition of carrageenan can improve cheese slicing and grating ability. The firmness of wheyless cream cheese may also be improved. The addition of kappa and iota--carrageenan increases the rigidity of processed cheese with different amounts of fat. However, processed cheese with carrageenan may be too hard and impossible to spread.

Carrageenan can be a good replacement for emulsifying salts to stabilize fat in the cheese production process without disturbing the Ca:P ratio. Increasing the amount of carrageenan results in a homogenous product, but differences in the amount of fat globules may occur. Cheese with both carrageenan and emulsifying salts added have increased shear modulus. Carrageenan may be a useful ingredient in cheese analogues and cheese imitations. The use of carrageenan as a cheese coating can be useful in cheese manufacturing and marketing.

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