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K-CARRAGEENAN EFFECTS ON TEXTURE CHARACTERISTICS OF MEAT EMULSIFIED SISTEMS

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ABSTRACT. A sausage mix with different quantities of k-carrageenan was tested out in order to determine their effect on the admixture rheology. Four levels of polysaccharide were used (0.25%, 0.5% 0.75% and 1%) with 30% and 40% brine percentages. The used proportion of meat to fat was 70/30. Viscoelasticity of the samples was observed with an AR2000ex rheometer and after cooking a texture analyzing test was performed in order to determine the Warner - Bratzler shear force. Results showed a big impact of ratio of added hydrocolloid on the rheological behavior and on cooking yield but there was no impact on batters` texture.

***Keywords**: K-carrageenan, creep, rheology, temperature ramp, Warner - Bratzler.*

INTRODUCTION

One of the most important characteristics of processed meat products is their texture [1], [2]. It depends on the structure of the matrix formed by the proteins gel and the moisture content. Lots of factors are involved in the matrix formation, such as protein, water holding capacity, salt, pH and non meat ingredients.

There is a tendency to equilibrate the quality with costs of the products, so manufacturers add different non meat ingredients in comminuted meat products in order to supplement the binder effect of the proteins and to replace meat and added fat with soya protein concentrate or hydrocolloids such as starch, xanthan or carrageenan [3], [4].

Polysaccharides are largely used in food products as they form a variety of different gels at room temperature. They are widely used as food thickening and stabilizing agents.

Obtained from red and brown seaweeds carrageenan is large, highly flexible molecules which curl forming helical structures. They are divided into three commercial groups: Kappa - a linear sulphated polysaccharide with strong, rigid gels that interfere with potassium ions and reacts with dairy proteins, obtained mainly from Eucheuma *cottonii*. Iota carrageenan provides soft gels,

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with calcium ions. Produced mainly from Eucheuma *spinosum;* and Lambda group that does not gels, mostly used to thicken dairy products [5]. A particular advantage is that carrageenan is pseudoplastic - they thin under shear stress. This means that they are easy to pump but stiffen again afterwards. The effect of the carrageenan addition on the functional properties of meat products is the subject of numerous studies.

Some researchers [6] have found that k-carrageenan addition caused an increase in solid like behavior of the product, hardness, gel strength and water holding capacity but they decline the carrageenan ability for the build-up of a three-dimensional gel network. In other case [7] was detected an increase in cooking yield and hardness when adding up to 2% k-carrageenan to low fermented meatballs.

The aim of this study was to observe the effect of different levels of added k-carrageenan and water content on texture characteristics of meat emulsion systems.

RESULTS AND DISCUSSION

Physico - chemical characteristics

Table 1. Meat batters physical characteristics

Sample composition		Dry matter, %	WHC cm^2/g	pH
Brine %	**k-carrag., %**			
Blank	-	35.64±1.2	4.6±0.5	5.7±0.5
30	0	30.63±0.9	0.6±0.02	5.6±0.4
30	0.25	30.62±0.8	0.4±0.02	5.6±0.5
30	0.5	30.59±0.5	0.1±0.01	5.7±0.5
30	0.75	31.85±0.9	-	6.0±0.2
30	1	31.99±1.2	-	6.1±0.3
40	0	29.62±0.9	0.8±0.01	5.5±0.4
40	0.25	29.74±0.8	0.2±0.02	6.0±0.3
40	0.5	29.88±0.6	0.2±0.01	5.7±0.2
40	0.75	30.17±1.0	-	5.6±0.3
40	1	30.25±1.1	-	5.9±0.2

For all samples, water holding capacity (Table 1) was very high ($p < 0.05$), namely there was found a little area of the released water for most of the samples, even for those with 40 % of added brine. In both cases the best water holding capacity with no water released was found in mince with 0.75% and 1% of added hydrocolloid. It can be observed an accession of dry matter values with the increasing rate of added k-carrageenan.

Cooking yield

The results of cooking yield are given in Figure 1. There can be seen that at 40% added brine, the yield was better for all cases.

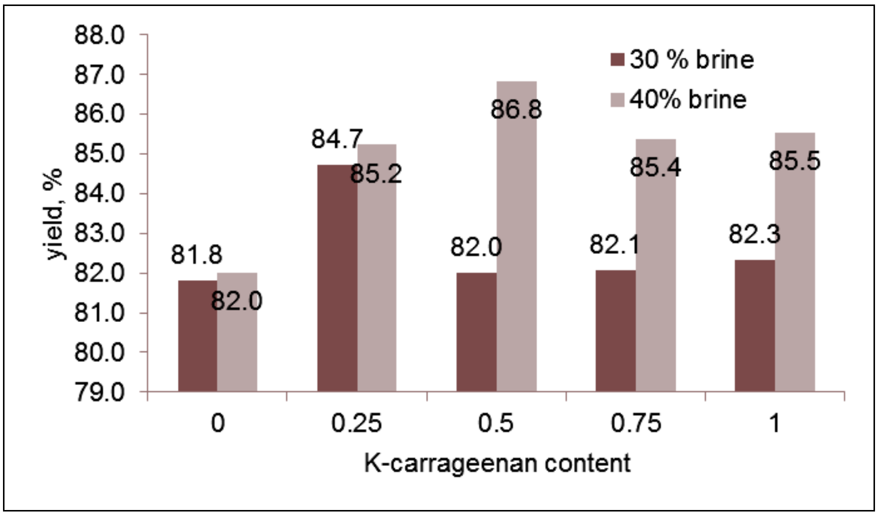

Figure 1. Graphical resemblance of cooking yield

This phenomenon can be explained in that at lower water content the structure of the admixture is denser which creates an expelling of water from the batters than at bigger percentages of content water. Another cause can be that at higher water content the gelling capacity of k-carrageenan is better, [8], [9], [10], [11], researchers have suggested that polysaccharide chains exist as a very weak, sparsely cross-linked network. On the other hand, the double helix model [12] and later modified to the domain model [13] is widely accepted. The domain model assumes that in the sol state at high temperature the carrageenan molecules exist as random coil and a temperature decrease induces the formation of double helixes. Intermolecular association through double helixes leads to the formation of small independent domains involving a limited number of chains. Aggregation of helices in different domains via cations enables more long-range cross-linking for the gel formation.

Rheological characteristics

The viscoelastic storage G` modulus, representing the elastic behavior of the sample, was measured over a frequency range of 0.1 to 10 Hz and a maximum strain of 1%. The results exposed in Figure 2 and Figure 3 shows a perfect correlation between G` values and the hydrocolloid concentration for both cases.

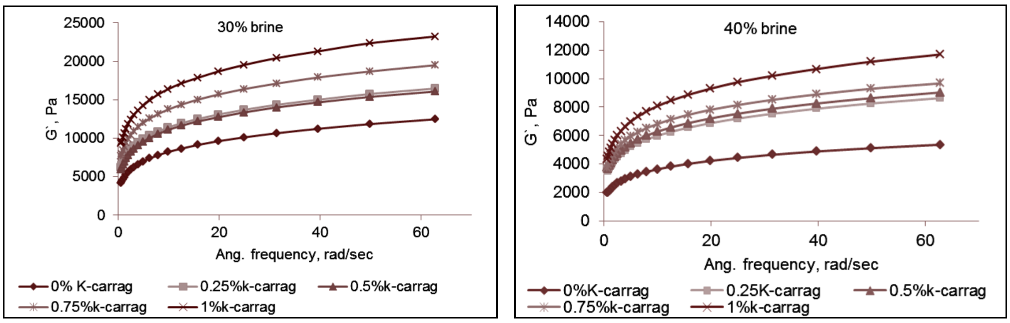

Figure 2. Storage modulus (G`), depending on angular frequency during oscillation test

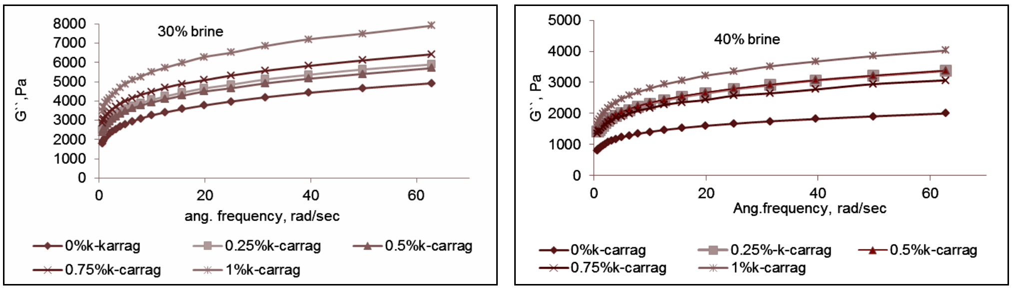

Figure 3. Loss modulus (G``) depending on angular frequency during oscillation test

But as opposed to samples with 30% of added brine with a maximum 24000 Pa for G` (1% k-carrageenan), those with 40% had a softer structure, with a maximum value of G` of 12000 Pa (1% k-carrageenan).

However the G`` values, representing the viscous behavior of a sample [14] were below G` values, indicating that the material is behaving more like a solid.

In the temperature ramp test, both moduli (Figure 4 and Figure 5) initially decreased until the coagulation point of the proteins at 40℃, when G` reached the lowest values, then it began to grow again as the protein mixture formed a strong structure till 70℃. The dynamic G` moduli was (as in previous test) larger then G``. The influence of the added k-carrageenan is visible in the differences between tendency of G` curves as much as between G`` curves. Researchers who studied hydrocolloid`s rheology found a similar behavior in gels subdued to temperature sweeping [15], [16], [17].

The biggest G` values had admixtures with the highest content of k-carrageenan, thus the ratio of hydrocolloid addition has a big impact in the solid like behavior of the samples at low temperatures but after heating all the samples had a similar behavior. That could mean that k-carrageenan loses its rheological characteristics after heating by entering in a rubbery zone and at high temperatures it remains there rather than crossing back into the terminal region [11].

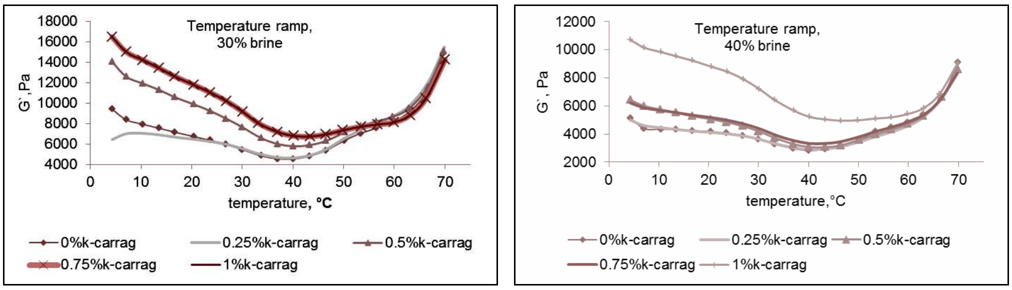

Figure 4. Storage modulus (G`) variation with temperature ramping.

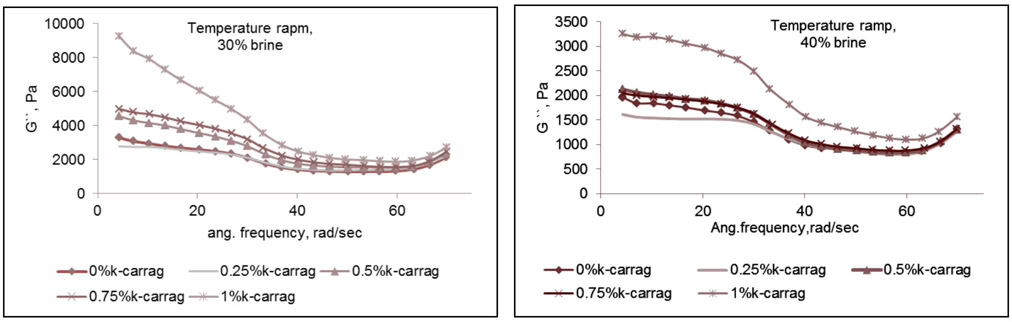

Figure 5. Loss modulus (G``) variation with temperature ramping.

The viscoelasticity characteristics of the samples were given by the rheological parameter δ, that represents the ratio of G``/G` [18]. The tan (δ) values obtained in the temperature ramp test (Table 2) showed a more solid like behavior of the materials. The best case for meat filling mixtures would be a range more closely to 45°, when the samples would have a purely elastic behavior. The biggest value of the shift angle had the sample with 40% brine and no k-carrageenan at all (17.49°), however admixtures with more brine had larger values of tan (δ) approaching more to elastic behavior.

Table 2. The average of shift angle (tan (δ)°), values during temperature sweep.

Brine conc.,%	0%k-carrag	0.25%k-carrag	0.5%k-carrag	0.75%k-carrag	1%k-carrag
30 %	16.07	16.48	15.79	15.51	14.87
40 %	17.49	16.53	16.54	16.20	15.74

Texture analysis

The results from the WB test showed significant differences for cutting force [19]. The averages of all data represented in Figure 6 as the firmness shows two tendencies, a growing in firmness for batters with 30% of added brine and a descendent one for those with 40 % of added brine.

The same behavior is seen for cooking yield, when batters with more brine for same amounts of k-carrageenan had the biggest values of yield.

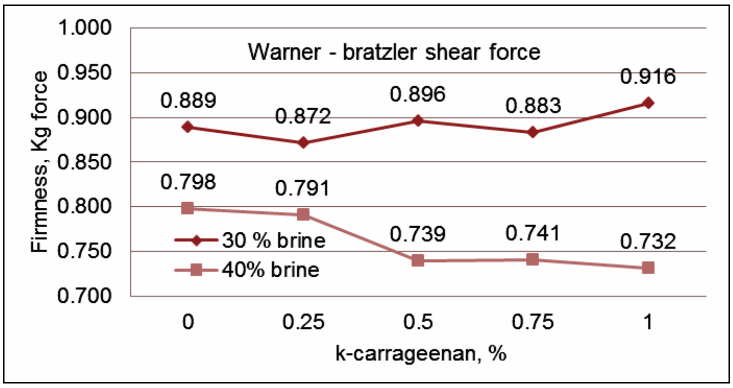

Figure 6. The firmness of butters expressed in Kg force.

CONCLUSIONS

The results of the present study show that the addition of k-carrageenan appeared to affect the rheological properties of the emulsified meat systems. The impact is seen at low temperatures, but after 40°C when the protein gelation starts there is no difference between samples. However, k-carrageenan appears to have a great impact on the cooking yield of butters at high quantities of brine, phenomenon that leads to a decrease in WB shear cutting force.

EXPERIMENTAL SECTION

Preparation of meat composition

In this study pork *gluteus maximus* muscle was used and back fat at a ratio of 70% to 30%. The materials were comminuted at 3000 rot/min for 3 minutes in a home chopper. A commercial k-carrageenan flower was added in four levels: 0%; 0.25%; 0.5%; 0.75% and 1%. There are studies in which k-carrageenan was used up to 3% [20], but they observed that carrageenan level of 3% negatively affected the firmness of the sausages.

The brine was then prepared from ice water, 2.5% of sodium chloride, 15 ppm sodium nitrite, 0.5% sodium polyphosphate, 0.015% ascorbic acid and 0.05% sucrose and the latest mentioned quantities of k-carrageenan in order to have a brine content of 30% and 40% from meat muscle. So that we had one blank probe with no brine and ten others with different levels of carrageenan in duplicate. The butters were let for 24 hours at 5°C prior to processing. Than they were manually stuffed into polyetilen casings, cooked for approximately 60 min until reaching an internal temperature of 72 ± 2 ℃.

Physico - chemical characteristics

Water holding capacity of the batters was measured with the filter paper press method [21], [22], with some modifications. A meat sample (0.3 g) was placed on a piece of filter paper, then placed between two Plexiglas plates and subjected to a force of 1Kg for 10 min. The water released (area of the moisture ring around the meat film area) was expressed per unit weight of meat sample (cm^2/g). Low value of cm^2/g means that the meat has superior water holding properties to meat with a high value of cm^2/g.

Cooking yield

The weight of each sample was taken before and after cooking and cooling. Cooking yield was calculated as:

$$Cooking\ yield = \frac{cook\ weight}{initial\ weight} \times 100\% \quad , \qquad (1)$$

Rheological characteristics

Rheological development of batters was tested out with an AR2000ex Rheometer from TA instruments. Rheological measurements were performed at 4℃, using parallel plates of 40mm diameter and a 1.5 mm gap. First the linear domain was determined with a *strain sweep step* by observing the γ_c (critical strain), the subsequent oscillation tests were carried out using a strain % below γ_c were the structure is intact [23]. *A frequency sweep step* was performed for further characterization of the structure of the material. This provides more information about the effect of colloidal forces and the interactions among particles.

At last *a temperature ramp* step was carried out by rising the temperature with 5℃/min, from 4℃ to 70℃ by using a Peltier p late. Than the G`, G`` and tan (δ) were stored in order to observe the rheological behavior of the admixtures.

For every step was used another sample so that we would prevent errors that could interfere from conformation damages. Edges of samples were covered with light silicone oil to prevent drying out.

Texture analysis

After cooking, samples were cooled at room temperature and the texture of the butters was determined by using a TA-XT plus Texture Analyzer with a Warner Bratzler blade set (HDP/BS) and a 25 Kg load cell [19] at a crosshead speed of 2 mm/s. The cutting force in compression was stored and the average value of each sample was recorded (mean of five replicates).

Statistical and data analysis

Where necessary, the test data were statistically analyzed by Anova single factor analysis of variance.

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