Scientific Papers. Series D. Animal Science. Vol. LVII, 2014
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN-L 2285-5750

EFFECTS OF VEGETAL OILS ON THE QUALITY CHARACTERISTICS OF BEEF MEAT PRODUCTS WITH LOW ANIMAL FAT

Felicia DIMA, Camelia VIZIREANU, Daniela ISTRATI

Faculty of Food Science and Engineering, "Dunărea de Jos" University of Galati,
111 Domneasca Street, Galati, RO 800008, Romania

Corresponding author email: fdima@ugal.ro

Abstract

Meat industry tries to modify his approach concerning the composition of its products for health purposes, to respect nutritional principles in processed foods. Many researchers propose partial substitution of animal fats with vegetable oils in food; these oils are rich in essential fatty acids, mono-and polyunsaturated. But it was observed that this substitution has affected sensory quality of compositions of meat in which the fat was replaced by vegetable oils. Study analysed the modification of the chemical compositions of the beef meatballs with low fat and the correlation with sensory analyse. Was effectuated rheological characterisation for all samples, were measured the storage modulus (G') and loss modulus (G''), indicating the viscoelastic character of the beef mincemeat with vegetal oils. This study tries to establish the acceptability of the meat products with partial replacing of the animal fat with some vegetal oils, in fact sunflower oil, canola oil and hemp oil. Finally, sensory analyses suggest that the use of beef meat products with these oils can be well accepted by the consumers because they are healthier.

Keywords: *beef mincemeat, canola oil, hemp oil, inulin, rheological characteristics.*

INTRODUCTION

The importance of the food consists in the nutritional compounds, proteins, lipids, carbohydrates which have important biological role and energy value. But the eating of high processed products, very concentrated in some of these compounds produces disagreements and increasing of obesity and cardiovascular diseases motivating the study of the causes of these disagreements.

Processed meat products contain high amounts of fat, related to chronic diseases such as obesity and cardiovascular illness. It was suggest by health organizations to reduce the intake of total dietary fat, particularly saturated fatty acids and cholesterol, to prevent cardiovascular heart diseases (NCEP, 1988; Moon et al., 2009).

Studies have shown that vegetable oils in meat products improves the nutritional quality by reducing caloric and cholesterol contents (Liu, et al., 1991; Paneras and Bloukas, 1994).

But reducing fat levels in meat products can lead to an unacceptable product texture, flavor and appearance (Miles, 1996).

In a same way, fats in meat products play important technological role in stabilizing meat emulsions, can reduce cooking loss and improve water holding capacity, provide juiciness and hardness (Karema A et al., 2011). It has considerable effects on the binding, rheological and structural properties of the meat product (Karema A et al., 2011).

In some studies it was demonstrated that replacing animal fat with soy products or carbohydrate is successful in textural and sensory properties of low-fat products (Moon et al., 2009)

Some researches reported that replacement of animal fat with vegetal oils may have a positive effect on consumer health, they are free of cholesterol and have a higher ratio of unsaturated fatty acids (Karema et al., 2011).

The reduction of animal fat in meat products and the substitution of animal fat with vegetable oils and dietary fibers could result in healthier products (Choi et al., 2009; Sanjeewa et al., 2010).

Olive oil has used in fermented sausages (Bloukas et al., 1997;Kayaardi et al., 2003; Koutsopoulos et al., 2008) and beef patties (Hur et al., 2008). Has been tasted partial replacement of pork back fat with olive oil in frankfurter sausages and low-fat products by (Jiménez-Colmenero et al., 2007; López-López et al., 2009) who reported an increased MUFA contents without significantly altering the n-6/n-3 ratio.

Dietary fibers (wheat bran, soy protein) have been used by (Moon et al., 2009) to emulsified meat low fat products, to support and ensure binding.

It was used canola oil, low in saturated fat and containing both omega-6 and omega-3 fatty acids in a very good ratio, 2:1. it was used. Many health professional organizations, including the Academy of Nutrition and Dietetics and American Heart Association, confirm that the consummation of canola oil it also reduces low-density lipoprotein and overall cholesterol levels, and represent a significant source of the essential omega-3 fatty acid. It was associated this with the reducing of cause and cardiovascular mortality by (Ryszard Rezler et al., 2007; O'Brien, 2008).

Our research is followed to obtain low fat beef mincemeat with vegetable oil and dietary fibers added, inulin, the proportions of oil going up to the total replacement of pork fat.

Compositions were characterized by physico-chemical and sensory analyze.

It was study the effect of the addition of vegetable fats on the structure and consistency of meat compositions, how the addition of oils affects the taste and appearance of these products and influences the acceptability of the consumers. The products have been designed for the catering sector.

MATERIALS AND METHODS

Material

The experiment consisted of 4 samples for each of three oils and one control. Was used pork fat and fresh beef meat, without bone and fat. Minced beef meat and pork fat were chopped at sieve of 5 mm. Pork fat was gradually replaced with oil from 30 to 100% of quantity (Table 1). Salt and inulin was incorporated, and the composition of meat was mixed for 15 minutes and stored at 2÷4°C for 12 hours. After, in the samples 1 to 4 it was mixed the corresponding quantity of oil, separately for each three types of oil, sunflower oil, canola oil and walnut oil.

Table 1. Recipe used in the experiments (%)

Specification	Control	Sample 1	Sample 2	Sample 3	Sample 4
Beef mincemeat	50	50	50	50	50
Animal fat	30	20	10	5	-
Oil	-	10	20	25	30
Inulin	-	4	4	4	4
Waterfor hydration and ice	20	20	20	20	20

The samples were subsequently analyzed for physical-chemical and rheological properties.

Oils used to replace the animal fat in meat paste were purchased from commercial or directly from the manufacturer. Inulin fibers were purchased from SC Enzymes & Derivates SA, Neamt.

Methods

Physical-chemical properties were determined for row material, beef meat and pork fat and for each composition with oil.

- water content: conforming AOAC method (1995);
- total content of nitrogen: according to SR ISO 9037 (2007) standard (for samples digestion and distillation was utilized by Kjeldahl Velp Scientifica UDK 127 System); protein degree of hydrolysis was estimated by the determination of non-protein nitrogen according to AOAC (1990) method and aminic nitrogen according to the method described by Vata et al. (2000);
- fat content: according to the AOAC (1984) method utilizing Fat Extractor SER 148;
- ash content: conforming AOAC 972.15;
- pH was determined according to A.O.A.C. method (1984) with a Hanna digital pH-meter;
- cooking loss: were calculated with the formula: P= [Mi-Mf] x 100/Mi, where Mi= initial weight of the sample (raw meat); Mf= final weight of the sample (after thermal treatment).

Determination of rheological characteristics

Rheological measurements were performed in triplicate, using a voltage controlled rheometer (AR 2000, TA Instruments, New Castle, DE) attached to computer control software (Rheology Advantage Data Analysis Program, TA, New Castle, DE). The temperature was monitored by using a Peltier temperature control system. Rheological measurements were made using plate geometry of 40 mm, with an angle of 2° and a gap of 1000 µm. The samples used were approximately 2.5 g of mincemeat for each test. It was placed on the bottom rheometer plate and low viscosity silicone was added around the plate edges to prevent dehydration. Measurements were made at constant frequencies (between 1 to 10 Hz) and different temperature (between 20 to 71,6^{o}C) in double samples. Changes in the storage (G') and loss (G'') modulus and the phase or deformation angle (δ) were recorded. For each test, the sample was maintained for 5 minutes to balance the temperature.

All the results were statistics analyzed.

RESULTS AND DISCUSSIONS

Physical-chemical properties

Compositions for uncooked and cooked products with oils are presented in Tables 1, 2, 3 and the sample was defined like that: Control- beef mincemeat and pork fat; Sample 1 – 30% of pork fat was replaced with oil; Sample 2 - 60% of pork fat was replaced with oil; Sample 3 - 85% of pork fat was replaced with oil; Sample 4 - 100% of pork fat was replaced with oil. The samples where it was used sunflower oil are presented in Table 2. It can observe significant differences in moisture, fat, and ash contents of the samples with sunflower oil face to control, protein contents were not significantly different. In fact, moisture contents of the samples with oil are higher than the control because in the samples was added more water, to hydrate the inulin.

This fact was observed by (Choi et al., 2007; Choi et al., 2008; Choi et al., 2009), when they added vegetable oil and dietary fibers to meat emulsions. Fibers have increased the moisture content of meat products and have produced higher water retention and improved emulsion stability.

Fat content was decreasing with the increasing of the replacement of pork fat with oil, with 20-35% in the samples with sunflower oil compared to control. These results agree with (Luruena-Martinez et al., 2004) who reported similar characteristics for low-fat frankfurters in which it was replaced the pork fat with olive oil. Ash content was higher with 10-15% for all samples containing sunflower oil face the control, in accordance with (Choi et al., 2008; Choi et al., 2009), who reported that the ash content is significantly increased in the low-fat meat products with the addition of rice bran fiber. Ayo et al. (2007) reported that ash content significantly increased with the addition of walnut to low-fat meat products. Others reported no significant difference in ash contents when vegetable oil replaced pork fat (Paneras et al., 1994).

In Table 3 are presented compositions with canola oil, for uncooked and cooked samples. The compounds of samples had significant differences in moisture, fat, and ash contents face to control, protein contents are the same. But it exist differences between the samples with sunflower oil and the samples with canola oil. It was observed that the moisture content is less and lipid content is higher for the products with canola oil. It can observe that the differences of moisture between the samples with sunflower oil and canola oil are 3.84-7.46%. Lipid content in the samples with canola oil is progressive decreasing but not so much than in the samples with sunflower. In the same time, viscosity of the mincemeat was better, probable because of high density and physico-chemical characteristics of canola oil. The compositions with hemp oil in a place of pork fat are presented in Table 4. There are no significant differences in the content of moisture of samples face the products with sunflower and canola oil. Lipid content is smaller than the sample with canola oil with 6.25-9.81%. Viscosity of mincemeat was better than the samples with sunflower but less than the samples with canola oil. pH results for the mincemeat are presented in the Figure 1. It can appreciate that the value for uncooked mincemeat present a progressive increase with small value, no more than 0.1-0.26 unit of pH, between 5.8-6.14. For cooked product results was higher with 0.4-0.8 unit, between 6.6-6.72, it was increasing at the samples 1 and 2, after it was decreasing to the end, as reported (Choi et al., 2009).

Table 2. Composition of beef mince where the pork fat was replaced with sunflower oil (%)

Uncooked					
Compounds	Control	Sample 1	Sample 2	Sample 3	Sample 4
Moisture	64.16±0.81	67.51±1.01	69.12±0.62	70.51±0.39	70.46±0.80
Proteins	20.40± 0.52	20.18± 0.33	19.41± 0.12	19.40± 0.17	19.57± 0.21
Lipids	13.22± 0.11	10.06± 0.23	9.58± 0.15	10.11± 0.41	8.52± 0.13
Ash	1.18± 0.03	1.22± 0.07	1.32± 0.08	1.29± 0.01	1.43± 0.06
Cooked					
Compounds	Control	Sample 1	Sample 2	Sample 3	Sample 4
Moisture	49.94±0.34	53.35±0.51	54.03±0.60	52.15±0.32	55.41±0.43
Proteins	28.23±0.35	25.76±0.74	25.78±0.88	26.98±0.81	25.16±0.64
Lipids	18.27±0.52	18.02±0.25	19.01±0.54	19.63±0.74	18.22±0.12
Ash	1.75±0.02	1.72±0.00	1.57±0.02	1.63±0.03	1.75±0.06

Table 3. Composition of beef mince where the pork fat was replaced with canola oil (%)

Uncooked					
Compounds	Control	Sample 1	Sample 2	Sample 3	Sample 4
Moisture	63.75±0.22	67.58±0.54	68.69±0.18	69.17±0.42	68.25±0.53
Proteins	20.59± 0.33	19.63± 0.47	20.18± 0.08	20.95± 0.53	21.44±0.24
Lipids	13.42± 0.18	11.76± 0.40	10.29± 0.07	9.46± 0.25	9.89± 0.09
Ash	1.23± 0.02	1.31± 0.05	1.40± 0.01	1.38± 0.00	1.34± 0.04
Cooked					
Compounds	Control	Sample 1	Sample 2	Sample 3	Sample 4
Moisture	48.56±0.21	49.37±0.18	51.62±0.42	53.60±0.56	53.28±0.48
Proteins	29.35±0.23	29.31±0.41	28.76±0.27	28.43±0.13	28.03±0.35
Lipids	19.31±0.16	18.94±0.09	17.93±0.33	16.01±0.28	16.14±0.06
Ash	1.84±0.00	1.83±0.07	1.62±0.04	1.71±0.01	1.78±0.12

Table 4. Composition of beef mince where the pork fat was replaced with hemp oil (%)

Uncooked					
Compounds	Control	Sample 1	Sample 2	Sample 3	Sample 4
Moisture	64.28±0.45	66.87±0.21	68.25±0.64	68.73±0.17	70.12±0.42
Proteins	20.03± 0.29	20.49± 0.18	19.57± 0.32	19.86± 0.33	20.38±0.14
Lipids	13.54± 0.21	10.85± 0.34	10.08± 0.45	8.86± 0.65	8.92± 0.45
Ash	1.35± 0.01	1.39± 0.02	1.37± 0.07	1.50± 0.12	1.37± 0.05
Cooked					
Compounds	Control	Sample 1	Sample 2	Sample 3	Sample 4
Moisture	49.36±0.37	50.23±0.54	52.94±0.46	52.73±0.27	53.69±0.43
Proteins	28.76±0.12	29.06±0.27	28.66±0.38	28.95±0.45	28.26±0.13
Lipids	19.12±0.48	19.57±0.13	19.03±0.27	18.81±0.41	15.14±0.24
Ash	1.78±0.06	1.75±0.03	1.80±0.15	1.62±0.09	1.73±0.18

Control- beef mincemeat and pork fat; Sample 1-30% of pork fat was replaced with oil; Sample 2 -60% of pork fat was replaced with oil; Sample 3 -85% of pork fat was replaced with oil; Sample 4 - 100% of pork fat was replaced with oil.

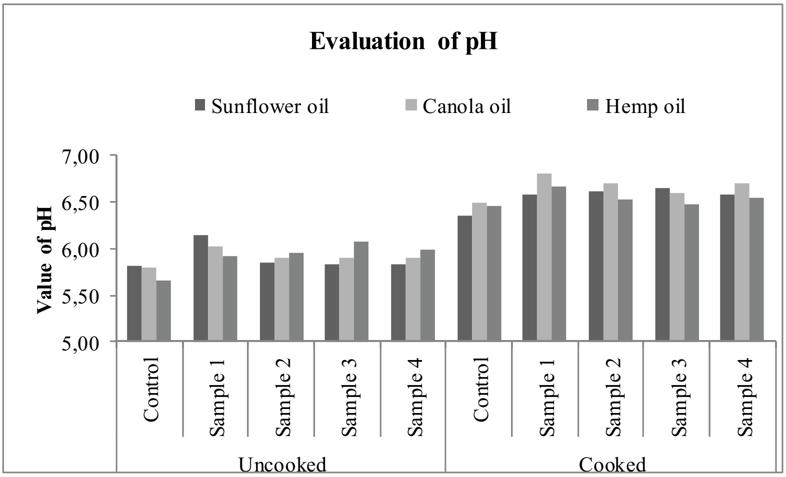

Figure 1. Evaluation of pH value for uncooked and cooked samples

Cooking loss values (Figure 2) have increased, but not linear, as the amount of pork fat is replaced with oil. For the samples with sunflower, cooking loss increase progressive, from 21.45% at the control to 23.71% at the sample 4, where all the pork fat was replaced with oil. The small cooking loss was obtained at the samples with canola oil, between 20.43-20.67%. These results were concordant with the good viscosity obtained for mincemeat with canola oil and the results reported by Choi et al. (2009), who find that the samples with canola and soybean oil had contained the lowest total expressible fluid at cooking.

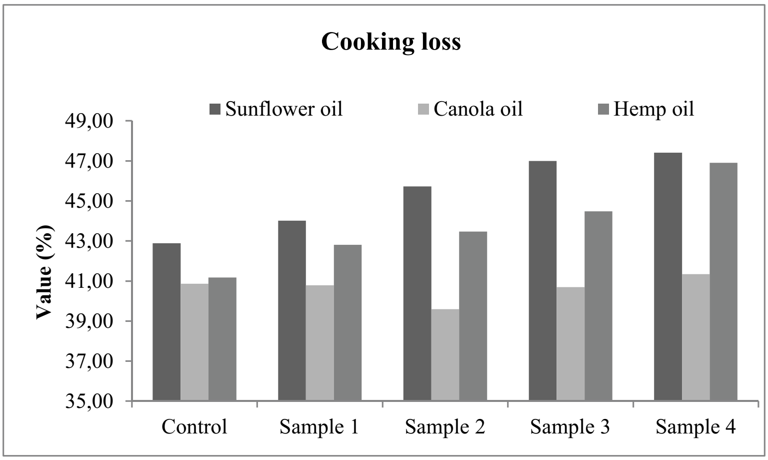

Figure 2. Evaluation of cooking loss of the samples

Dynamic rheology tests

Frequency sweep test for mincemeat and dynamic frequency tests were carried out within the limits of viscoelastic range to determine the frequency dependence of storage and loss modulus (G’ and G”).

Storage modulus (G') and loss modulus (G") was analyze for beef mincemeat with different percentage of replacement of pork fat with each oil, sunflower oil, canola oil and hemp oil.

It can observe that the rheological response was difference for each sample, in correlation with the composition and the type of oil.

With the increasing of temperature, rheological properties were affected by the structural changing, elastic module were increasing,

observation reported by (Marchetti et al., 2012).
It was obtained an inflection point at 43°C, where the proteins began to coagulate and mincemeat with oil went from the state of viscous fluid at the state of elastic gel with soft texture.
Increasing of temperature over 43°C have produced an increase of consistency of all samples, the last scan give close values of the storage modulus (G'). Possible explanation consist in denser structure of the mincemeat obtained by addition of salt and inulin and the storage for 12 hours at 4°C, period who have permitted to format a protein network in the meat paste. After this point of inflexion from 43°C, consistency of mincemeat decreased progressively with increasing temperature.

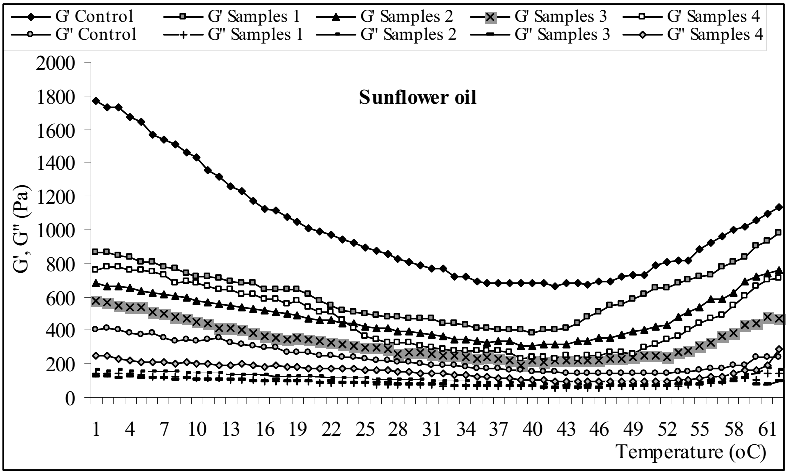

Figure 3. Rheological properties for the samples with sunflower oil.
Storage (G') and los modulus (G") depending by the temperature

In Figure 3, for the samples with sunflower oil it can observe that the storage modulus (G') has proved that control had the best rheological properties. For the samples with oils, value of storage modulus (G') was lower face the control and their behavior was quite similar. In order, the higher rheological properties were for the samples 1 (30% replacement of the pork fat), samples 4 (100% replacement of the pork fat), samples 2 (60% replacement of the pork fat) and, finally, samples 3 (85% replacement of the pork fat).
Loss modulus (G") confirms that the beef mincemeat with sunflower oil has a good viscosity and can be used in cooked products with low animal fat.
In the Figure 4 it can observe the difference face samples with canola oil. Mincemeat with canola oil it have the largest value of the modulus G', samples with total replacement of pork fat with oil have a higher rate of consistency compared to other samples.
Conclusion is that replacing of the fat with canola oil favored the formation of a protein network which improved elasticity of the gel. Result is confirmed by Senouci et al. (1988), who found that the fat replacing with some vegetable oils permit to form a protein matrix extended in the emulsion, who produce an increase in the viscoelastic parameters.
Storage modulus (G') values are higher than mincemeat samples with sunflower oil with approximate 12% and the elasticity of product is smaller, probably because of its higher viscosity and composition, who contribute to increase the consistency of mincemeat in the conditions we compared with others oils used in the experiment.

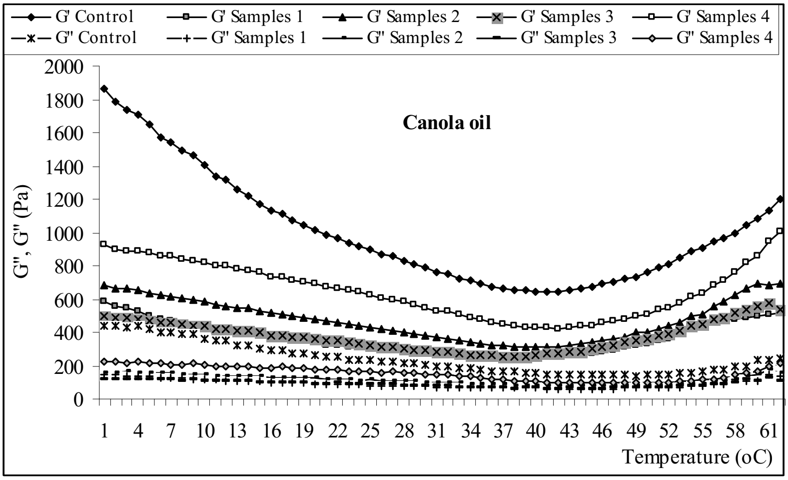

Figure 4. Rheological properties for the samples with canola oil.
Storage (G') and los modulus (G") depending by the temperature

Figure 5 shows that the samples with hemp oil have a different behavior face the samples with sunflower and canola oil, the order of the results confirm that total replacement of pork fat with oil permit mincemeat with good rheological characteristics, better than samples 1 to 3. Samples with oils allow incorporation of more water and have a lower consistency, so G' value is lower.

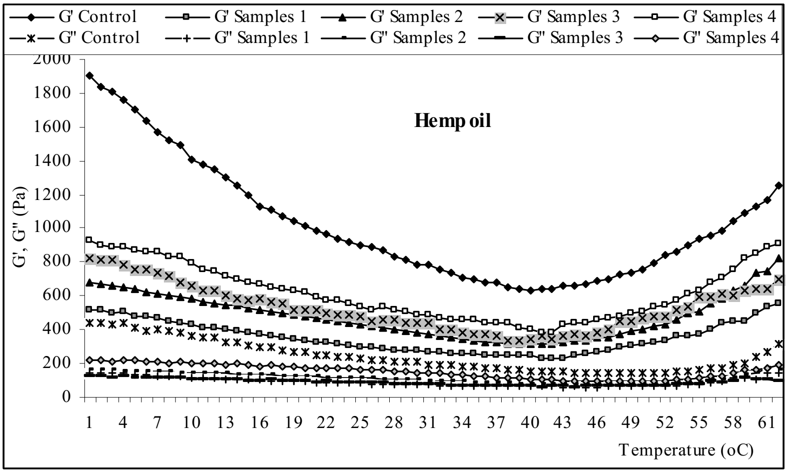

Figure 5. Rheological properties for the samples with hemp oil.
Storage (G') and los modulus (G") depending by the temperature

Storage modulus (G') value were higher for all samples than the values of G", this indicates a predominance of elastic properties compared with the viscous. Experiments confirms that a good gel is characterized by a proportional change of modulus G' and G" in the case of frequency sweep in a wide range, reported by Park et al. (2008).

Mincemeat behavior is consistent with mechanical spectra obtained for polysaccharide gels, where G' is always much higher (about 10 times) than G" and is practically independent of the applied frequency range, conclusion reported by Fernández-Ginés et al. (2005).

With increasing of storage modulus (G') it is increased loss modulus (G") at increasing of frequency oscillations, possibly due to structural changes in the systems. At scanning at the temperature between 20 to 71.6°C, loss modulus (G") had a similar pattern to that of the storage modulus (G') but in lower values.

It can estimate that the analysis of storage modulus (G') and loss modulus (G") depend on frequency applied on the mincemeat and show, at addition of oil, it decreases the consistence of mincemeat.

CONCLUSIONS

The study permitted to analyze some meat compositions with beef meat, in which was partially or totally replaced the pork fat.

The results show that the addition of vegetal oils can be useful for preventing lipid oxidation of cooked products.

Added inulin can help to increase the percentage of replacement of the pork fat in the meat products.

Reduction of pork fat content in percentage of 30-100% has determined a softening of the mincemeat and an increasing of the cooking loss with 12-14%.

Acceptability of products decreased with increasing of amount of vegetal oil used, and after 50% of the replacement the consumers don't agree the taste of cooked products.

It can conclude that the products obtained are acceptable in terms of technology, because pork fat replacement with vegetable oils produces lower consistency of mincemeat face the control. Adding inulin with oils it was improved the texture and consistency has favored the formation of a protein network, forming a gel with increased elasticity.

The study showed that vegetable oils used to replace pork fat in some mincemeat are an alternative to improve the nutritional value of meat for catering sector. We believe that this researches contribute to a new approach in this new culinary technology, that will reflect an improved of nutritional value of products, beneficial to health.

REFERENCES

Álvarez D., Barbut S., 2013. Effect of inulin, β-Glucan and their mixtures on emulsion stability, color and textural parameters of cooked meat batters, Meat Science 94, p.320–327.

Álvarez D., R.M. Delles, Y.L. Xiong, M. Castillo, F.A. Payne, J. Laencina, 2011. Influence of canola-olive oils, rice bran and walnut on functionality and emulsion stability of frankfurters, Food Science and Technology, 44, p.1435-1442.

Álvarez D., Y.L. Xiong, M. Castillo, F.A. Payne, M.D. Garrido, 2011. Textural and viscoelastic properties of pork frankfurters containing canola–olive oils, rice bran, and walnut, Meat Science 92 (2012), p. 8–15.

Andre´s S.C., M.E. Garcı´a, N.E. Zaritzky, A.N. Califano, 2006. Storage stability of low-fat chicken sausages, Journal of Food Engineering 72, p.311–319.

Andrés S. C., Pennisi S. C., Ranalli N., Zaritzky N. E., Califano A.N., 2012. Healthier functional beef burgers. In B. P. Hendriks, (Ed.), Agricultural research updates, Vol. 2, p.185-211. Nueva York: Nova Science Publishers, Inc. in press.

Andrés S.C., Zaritzky N.E., Califano A.N., 2009. Innovations in the development of healthier chicken sausages formulated with different lipid sources. Poultry Science, 88, p.1755-1764.

Andrés S.C., Zaritzky N.E., Califano, A.N., 2008. Stress relaxation characteristics of low-fat chicken sausages made in Argentina. Meat Science, 79, p.589-594.

Ayo J., Carballo M.T., Jiménez-Colmenero F., 2005. High pressure processing of meat batters with added walnuts. International Journal of Food Science and Technology, 40, p.47-54.

Ayo J., J. Carballo, M.T. Solas, F. Jime´nez-Colmenero, 2008. Physicochemical and sensory properties of healthier frankfurters as affected by walnut and fat content Food Chemistry 107, p.1547–1552.

Bais D., Trevisan A., Lapasin R., Partal P., Gallegos C., 2005. Rheological characterization of polysaccharide-surfactant matrices for cosmetic o/w emulsions.Journal of Colloid and Interface Science, 290, p.546-556.

Barbut S., Choy V., 2007. Use of dairy proteins in lean poultry meat batters e acomparativestudy. International Journal of Food Science&Technology, 42, p.453-458.

Begoña O.-A., Colmenero F.J., Sánchez-Muniz F.J., 2013. Development and assessment of healthy properties of meat and meat products designed as functional foods Meat Science 95, p.919–930.

Cengiz1 E., Gokoglu N., 2007. Effects of fat reduction and fat replacer addition on some quality characteristics of frankfurter-type sausages, International Journal of Food Science and Technology, 42, p.366–372.

Choi Y.S., Choi J.H., Han D.J., Kim H.Y., Hyun-Wook M.A.L., Jeong K.J.Y., 2009. Characteristics of low-fat meat emulsion systems with pork fat replaced by vegetable oils and rice bran fiber. Meat Science, 82, p.266-271.

Fernández-Ginés J.M., Fernández-López J., Sayas-Barberá E., Pérez-Álvarez J. A., 2005. Meat products as functional foods: A review, Journal of Food Science, 70, p.37–43.

Fernández-Martín F., Cofrades S., Carballo J., Jiménez-Colmenero F., 2002. Salt and phosphate effects on the gelling process of pressure/heat treated pork batters. Meat Science, 61, p.15-23.

Fernández-Martin F., López-López I., Cofrades S., Jiménez-Colmenero F., 2009. Influence of adding Sea Spaghetti seaweed and replacing the animal fat with

olive oil or a konjac gel on pork meat batter gelation. Potential protein/alginate association. Meat Science, 83, p.209-217.
Gibbs R.A., Rymer C., Givens D.I., 2013. Fatty acid composition of cooked chicken meat and chicken meat products as influenced by price range at retail, Food Chemistry 138, p.1749–1756.
Gök V., Akkaya L., Obuz E., Bulut S., 2011. Effect of ground poppy seed as a fat replacer on meat burgers Meat Science 89, p.400–404.
Hadorn R., P. Eberhard, D. Guggisberg, P. Piccinali, H. Schlichtherle-Cerny, 2008. Effect of fat score on the quality of various meat products, Meat Science 80, p.765–770
Jiménez-Colmenero F., S. Cofrades, A.M. Herrero, F. Fernández-Martín, L. Rodríguez-Salas, C. Ruiz-Capillas, 2012. Konjac gel fat analogue for use in meat products: Comparison with pork fats, Food Hydrocolloids 26, p.63-72.
Jiménez-Colmenero F., S. Cofrades, A.M. Herrero, F. Fernández-Martín, L. Rodríguez-Salas, C. Ruiz-Capillas, 2012. Konjac gel fat analogue for use in meat products: Comparison with pork fats, Food Hydrocolloids 26.
Karema A. M., Hesham M. Badr, 2011. Quality Characteristics of Gamma Irradiated Beefburger Formulated with Partial Replacement of Beef Fat with Olive Oil and Wheat Bran Fibers Food and Nutrition Sciences, 2, p.655-666.
Koistinen L., E. Pouta, J. Heikkilä, S. Forsman-Hugg, J. Kotro, J. Mäkelä, M. Niva, 2013. The impact of fat content, production methods and carbon footprintinformation on consumer preferences for minced meat, Food Quality and Preference 29, p.126–136.
Marchetti L., S.C. Andrés, A.N. Califano, 2013. Textural and thermal properties of low-lipid meat emulsions formulated with fish oil and different binders, Food Science and Technology 51, p.514-523.
O'Brien R., 2008. Fats and Oils Formulating and Processing for Applications, Third Edition: Formulating and Processing for Applications. CRC Press. p. 37–40, ISBN 1420061666.
Petersson K., Godard O., Eliasson A.C., Tornberg E., 2014. The effects of cereal additives in low-fat sausages and meatballs. Part 1:Untreated and enzyme-treated rye bran, Meat Science 96, p.423–428.
Petersson K., Godard O., Eliasson A.C., Tornberg E., 2014. The effects of cereal additives in low-fat sausages and meatballs. Part 2:Rye bran, oat bran and barley fibre, Meat Science 96, p.503–508.
Pińero M.P., K. Parra, N. Huerta-Leidenz, L. Arenas de Moreno, M. Ferrer, S. Araujo, Y. Barboza, 2008. Effect of oat's soluble fibre (b-glucan) as a fat replacer on physical, chemical, microbiological and sensory properties of low-fat beef patties, Meat Science 80, 675–680.
Reya J.F., Gualdornb L., 2011. The effect of the addition of vegetable oils in the mass and energy efficiency of meat derived product, low in saturated fat from buffalo meat (Bubalus Bubalus), Procedia Food Science 1, p.408 – 412.
Rezler R., 2007. The effect of the plant fat akoroma om on the mechanical properties of finely comminuted sausage batters, Acta Agrophysica, 9(1), p.209-219.
Rodr´ıguez Furl´an L.T., Padilla A.P., Campderr´os M.E., 2013. Development of reduced fat minced meats using inulin and bovine plasma proteins as fat replacers, Meat Scienc, doi: 10.1016/j.meatsci.
Senouci A., Smith A. C., 1988. An experimental study of food melt rheology. I. Shear viscosity using a slit die viscometer and a capillary rheometer, Rheologica Acta, 27, p.546-554.
Serdaroglu M., 2006. Improving low fat meatball characteristics by adding whey powder, Meat Science 72, p.155–163.
Tomaschunas M., Zörb R., Fischer J., Köhn E., Hinrichs, Mechthild Busch-Stockfisch J., 2013. Changes in sensory properties and consumer acceptance of reduced fat pork Lyon-style and liver sausages containing inulin and citrus fiber as fat replacers, Meat Science 95, p.629–640.
Youssef M.K., S. Barbut, 2009. Effects of protein level and fat/oil on emulsion stability, texture, microstructure and color of meat batters, Meat Science 82, p.228–233.
Youssef M.K., S. Barbut, 2011. Fat reduction in comminuted meat products-effects of beef fat, regular and pre-emulsified canola oil, Meat Science, 87, p.356.
Yun-Sang Choi, Ji-Hun Choi, Doo-Jeong Han, Hack-Youn Kim, Mi-Ai Lee, Hyun-Wook Kim,Ju-Woon Lee, Hai-Jung Chung, Cheon-Jei Kim, 2010. Optimization of replacing pork back fat with grape seed oil and rice bran fiber for reduced-fat meat emulsion systems, Meat Science 84, p.212–218.
Yun-Sang Choi, Ji-Hun Choi, Doo-Jeong Han, Hack-Youn Kim, Mi-Ai Lee, Hyun-Wook Kim, Jong-Youn Jeong, Cheon-Jei Kim, 2009. Characteristics of low-fat meat emulsion systems with pork fat replaced by vegetable oils and rice bran fiber, Meat Science 82, p.266–271.
Yun-Sang Choi, Ji-Hun Choi, Doo-Jeong Han, Hack-Youn Kim, Mi-Ai Lee, Hyun-Wook Kim,Ju-Woon Lee, Hai-Jung Chung, Cheon-Jei Kim, 2010. Optimization of replacing pork back fat with grape seed oil and rice bran fiberfor reduced-fat meat emulsion systems, Meat Science 84, p.212–218.
Zorba Ö., Kurt S., 2008. The effects of different plant oils on some emulsion properties of beef, chicken and turkey meats, International Journal of Food Science and Technology, 43, p.229–236.