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ORIGINAL RESEARCH PAPER

COMPARATIVE SENSORY ANALYSIS OF PRODUCTS WITH LOW ANIMAL FAT MEAT COMPOSITIONS

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Public concern for a healthy diet led to significant changes in the approach to food composition and nutritional principles by specialists in nutrition processed foods.
In recent years researches in the meat industry were aimed at replacing animal fats with vegetable fats (oils), rich in essential fatty acids mono-and polyunsaturated. It was found that the existence of equilibrium in the human diet is some correlations between macronutrients and biologically active substances in food, which ensures the normal functioning of the body. In these experiment we observed how it was affected the sensory quality of compositions of chicken mincemeat in which the fat was gradually replaced by vegetable oil, sunflower oil, canola oil and walnut oil. In parallel the color parameters (CIELAB method) of the low fat meat compositions were analyzed to determine how the animal fat replacement procedure affects the color of chicken minced.
Sensory acceptability of the products was medium for the compositions in which the replacement of fat with oils was up to 60%, the best results being recorded for sunflower oil. The brightness value initially increased, but color parameters decreased, and acceptability of products decreased with increasing of oil amount. The correlation between the two types of measurements led to clear conclusions regarding the consumers' acceptability of these products, obtained by adding varying amounts of oils.

Keywords: chicken mincemeat, animal fat, vegetable oils, colour analysis, texture, mouthfeel, taste, color

Introduction

Clinical studies show that meat products that use animal fat are responsible for the increased incidence of cardiovascular disease because high content of saturated fatty acids leads to accumulations of cholesterol deposits in blood vessels, which affects the health of blood vessels and cause their premature aging (Choi *et al.*, 2010). In this context the recommendation of nutritionists is to avoid animal fats as much as possible and try to use increased amounts of vegetable oils in the diet (Choi *et al.*, 2010).

Vegetable oils are rich in poly-unsaturated essential fatty acids and have a better proportion between the components of omega 3 and 6.

Studies have shown that partial or total replacement of animal fat with different quantities of olive oil or canola oil can decrease the cholesterol level of products. (Candogan *et al.*, 2003; Choi *et al.*, 2010)

Others researchers report that addition of fibers and vegetable oils has led to improved nutritional and technological properties, important health benefits; dietary fibers content was substantially improved the texture from mincemeat. (Álvarez *et al.*, 2012; Álvarez *et al.*, 2011; Choi *et al.*, 2010)

Vegetable oils have a positive effect on improving the yield and texture of meat products in which it replaced some animal fat. (Álvarez *et al.*, 2012; Álvarez *et al.*, 2011; Kumar *et al.*, 2004)

On the other side, it is recognized that replacing animal fat with oils and other ingredients may cause changes in emulsion stability. (Candogan *et al.* 2003; Choi *et al.*, 2009; Fernández-Ginés *et al.*, 2005)

Other autors (Choi *et al.*, 2009) accept that cooking loss and overall acceptability of products were influenced by the addition of certain vegetable oils, which could improve nutritional quality without affecting the palatability.

The sensory quality of low-fat products was affected by the addition of oils and dietary fiber. (Kumar *et al.*, 2004; Severini *et al.*, 2003)

Often consumers reject meat products that contain vegetal oil and fibers because the flavor, texture and consistency are nonspecific. (Candogan *et al.*, 2003; Emel *et al.*, 2007; Severini *et al.*, 2003)

The objective of our study was to establish an optimal pork fat replacement with vegetable oil in order to formulate compositions of poultry mincemeat for catering. Experiments watched establish the effect on the color and acceptability of the cooked balls in the case of the replacement of pork fat with different vegetable oils.

Material and Methods

All materials were purchased from the local market (Galati, Romania). Inulin fiber was purchased from SC Enzymes & Derivates SA Piatra Neamt. Deboned and skinless chicken breast and pork fat were used to formulate the chicken mincemeat; these materials were purchased from supermarket in a chilled state (2-4^{o}C) and stored for a day before use. The sunflower oil, canola oil and walnut oil were used in the research to replace the fat of animal original.

Design of experiments

Each experiment consisted of 5 samples, a control sample and four samples in which pork fat was replaced gradually, in varying proportions, with one of the three types of oil, sunflower oil, canola oil, and walnut oil.

Fresh meat and pork fat were separately chopped through a 5-mm sieve. For every sample, 200 g meat and a certain quantity of fat were taken and were then mixed for 15 minutes with the established quantity of water. After mixing, salt and inulin were incorporated in the paste and homogenized. Mincemeat was stored at 2-4°C for 12 hours before adding the vegetable oil. The mixing operation was performed under mixing for 10 minutes, using the established quantity of ice.

Details of the composition of each type of mincemeat are presented in Table 1.

Table 1. Recipe meat paste used in the experiments (%)

Specification	Control	Sample 1 P1	Sample 2 P2	Sample 3 P3	Sample 4 P4
Chicken breast meat	47.77	47.77	47.77	47.77	47.77
Animal fat	23.89	15.92	7.96	3.98	-
Oil	-	7.96	15.92	19.90	23.89
Salt	0.36	0.36	0.36	0.36	0.36
Inulin	3.98	3.98	3.98	3.98	3.98
Water for hydration	14.33	14.33	14.33	14.33	14.33
Ice	9.55	9.55	9.55	9.55	9.55
Thyme	0.12	0.12	0.12	0.12	0.12
	100.00	100.00	100.00	100.00	100.00

So the samples were defined as follows:

- Composition only with added pork fat - sample blank (control);

- Compositions where pork fat is replaced by sunflower oil in different proportion: P1F (33.3%), P2F (66.6%), P3F (83.3%) and P4F (100%);

- Compositions where pork fat is replaced by canola oil in different proportion: P1R (33.3%), P2R (66.6%), P3R (83.3%) and P4R (100%);

- Compositions where pork fat is replaced by walnut oil in different proportion: P1N (33.3%), P2N (66.6%), P3N (83.3%) and P4N (100%).

Samples were subsequently analyzed for the color and sensorial properties, in triplicate. In order to be prepared for sensory analysis, samples were cooked at 180^{o}C, on the plate.

Color analysis of mincemeat samples

CIELAB method was used for color analysis. The method involves using a lighting system and a digital camera to capture high resolution images of the uncooked samples. The system consisted of two light source lamps of cool and white light, mounted on a wood parallelepiped, painted black, at 25cm and at an angle of 45° to the sample plane. Digital camera NIKON COOLPIX L26 model was mounted on a tripod, with the lens pointing towards the fresh samples for to make high definition pictures. Photoshop CS6 software was used for processing color parameters of the samples. To convert the values obtained for L, a, b from the histogram in values for L*, a*, b* the following formulas were used:

$L^* = (L/255) \times (100)$

$a^* = (240\, a/255) - 120$

b* = (240 b/255) - 120

Sensory analysis of samples

Sensory analysis of samples was achieved by a group of 10 panelists belonging Sensory Analysis Laboratory of Department of Faculty of Food Science and Engineering, Dunarea de Jos University of Galati, Romania. They appreciated the appearance of the samples section, the color, texture, taste, smell and mouthfeel for all four variations of meat composition (three oils used in the experiments and control sample) all of them being cooked. The panelists have given scores from 1 to 5 for each attribute examined (1-very good, 5-very bad) and finally they performed a preference test on the types of oil.

Determination of sodium chloride

The content of sodium chloride was determined using the Mohr method.

Results and discussions

Assessment of mincemeat color

The uncooked samples were analyzed to assess the extent to which the color of mixture of mincemeat with pork fat was affected by the replacement of the fat of animal origin with vegetable oils.

The color parameters of the samples were processed with Photoshop CS6 software and were converted in values from histogram. The color of the samples was graphically represented by three parameters of white: L* (lightness), a* (from green to red) and b* (from blue to yellow). Then the control sample parameters were compared with the evolution of color parameters of mincemeat with oil, also uncooked.

Lightness (L*). For all tested samples the values of the lightness (L*) were higher than 50% (Figure 1). It can be concluded that the amount of oil affects the samples lightness and color, and our results are in agreement with other researchers' findings (Biswas *et al.*, 2011; Álvarez *et al.*, 2011).

Samples P1, P2 and P3 have a similar lightness, the difference is very small, on the other hand the sample P4, in which the fat is replaced entirely with oil, had a value of L* higher than the rest of the sample.

Lightness of mincemeat with sunflower oil increased with increasing the amount of animal fat replaced. This observation is not valid for the samples with canola oil and walnuts oil, and our results are in agreement with the findings of Álvarez *et al.* (2011). Mincemeat with canola oil and nuts showed non-uniform lightness values. Non-uniform evolution of lightness can be caused by the white background and the caractheristics of oils.

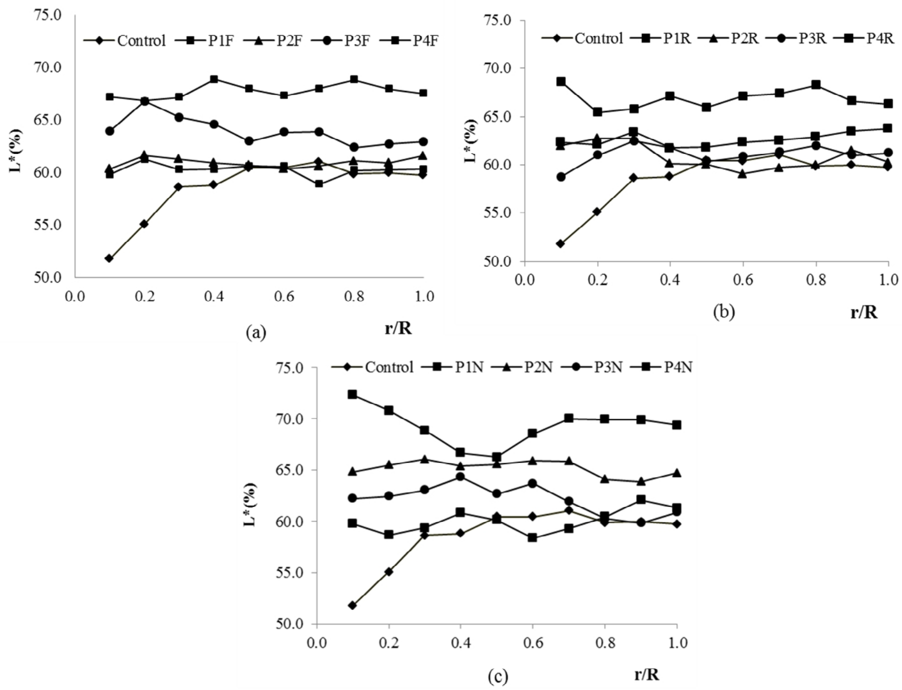

Figure 1. Evaluation of the lightness (L*) of the samples
a) mincemeat with sunflower oil (F); b) mincemeat with canola oil (R); c) mincemeat with walnuts oil (N). The r/R is the ratio between the current radius and maximum radius of the objective.

Parameter a*. Analyzing the graphics from Figure 2(a, b, c) one can note the decrease of the values of parameter a*, with increasing of the amount of oil (Álvarez *et al.*, 2011), regardless of the type of oil which replace the fat of animal origin. In other words, oil influences the red color; a greater percentage of oil added induces a decrease of red color of samples and an increase of green color.

The control sample, which has no oil in the composition, had the most pronounced red color, while the P4 samples, which had only vegetable oil, had reduced red color. Samples with walnut oil induced the largest attenuation of red color of all the samples. We consider that the nonlinear values of parameter a*, from inside to outside, can be caused by the differences in the characteristics of oils and non-uniformity of material.

Parameter b*. In the experiment it was found that the yellow color of samples has increased with increasing the amount of added oil. This observation is valid for all studied oils and is in agreement with Álvarez *et al.* (2011). However, mincemeat with canola oil gives a more pronounced yellow color than walnuts oil and sunflower oil. This is due to the intense natural yellow color of canola oil and its coloring strength, element confirmed in Figure 3, where it can be seen that the values of parameter b* are double compared to the walnuts oil and sunflower oil values.

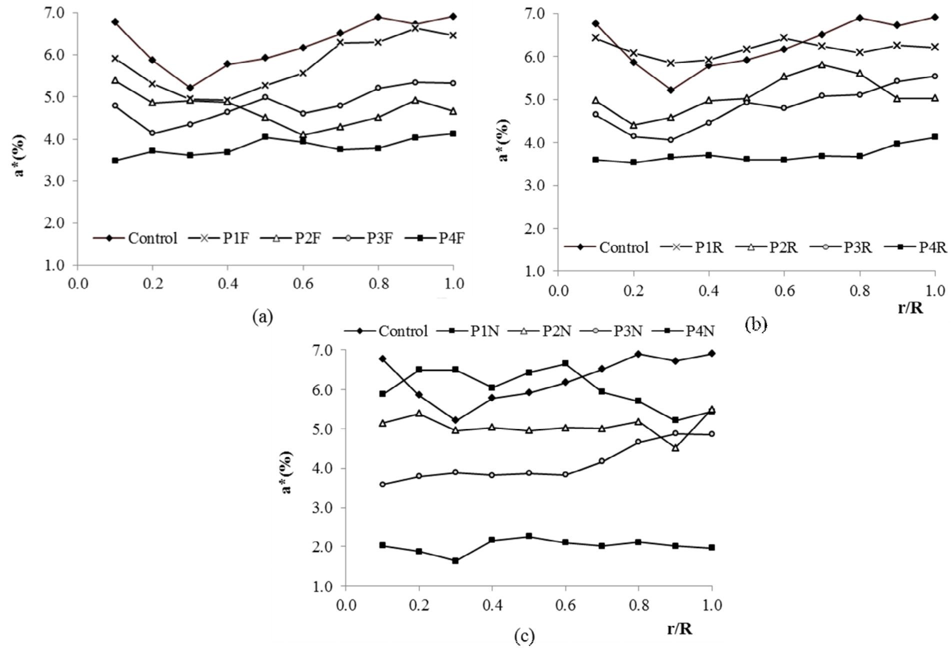

Figure 2. Evaluation of parameter a* (degree of red) of the sample
a) mincemeat with sunflower oil (F); b) mincemeat with canola oil (R); c) mincemeat with walnuts oil (N). The r/R is the ratio between the current radius and maximum radius of the objective.

Non-linear evolution of parameter b* values may be due to non-uniform distribution of the ingredients, as in case of the other color parameters, L* and a*.

Sensory analysis

Samples were tested for each type of meat composition, for each type of oil, on cooked meatballs.

A group of 10 panelists were given scores from 1 to 5 for each attribute examined, the overall score did not exceed the average values for any of the options, and the scores were pretty close in value (Figure 4).

The *appearance* of the samples was rather well perceived by the panelists. For the compositions with sunflower oil, the scores of appearance varied between 3.43-3.58. In terms of sensory appreciation, between all compositions with sunflower oil, the sample 2 was well appreciated but the sample 3 was less appreciated. The compositions with walnuts oil were appreciated for the appearance with scores between 3.41-3.51, similar to samples with sunflower oil. But compositions with canola oil have obtained the best scores for appearance, between 3.62-3.69, more homogeneous, that means the products were more appreciated than the other two.

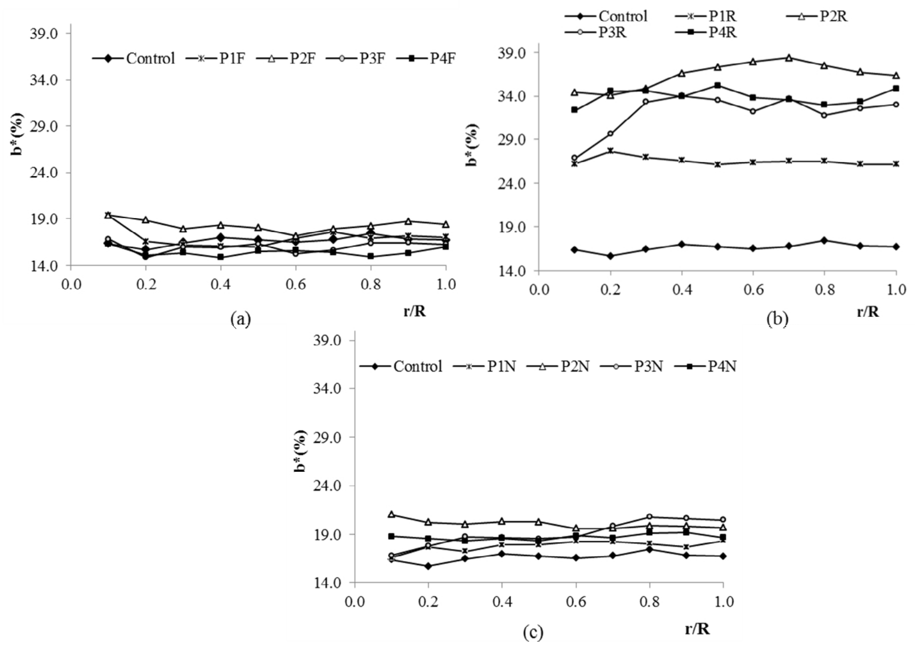

Figure 3. Evaluation of parameter b* (degree of yellow) of the sample
a) mincemeat with sunflower oil (F); b) mincemeat with canola oil (R); c) mincemeat with walnuts oil (N). The r/R is the ratio between the current radius and maximum radius of the objective.

The *color* was less appreciated, having a score lower than 3, and was considered unsatisfactory for all samples.

Concerning the *odor*, the control sample was rather well appreciated with respect to all samples based on vegetable oils. For the products with sunflower oil the scores were between 2.80 and 3.10. Sample 2 was better appreciated having a score of 3.10. The maximum score was obtained for sample 2 with canola oil, which received 3.13 and the samples 1 with walnuts oil, who have receive 3.27. Lower scores, bellow 3, were obtained for samples with maximum quantity of oil.

The *taste* received the smallest scores, around the value of 2, unsatisfactory for all samples. Samples with sunflower oil have received values between 2.08-2.18 but samples with walnuts oil have received values around 2.17, regardless of the percentage of oil used. Samples with canola oil were unsatisfactory, and received many individual evaluation scores under 2. No pronounced taste (salty, sweet, sour or bitter) was perceived by the panelists. Smell of ripe was considered to be the most satisfactory, particularly for samples with sunflower oil.

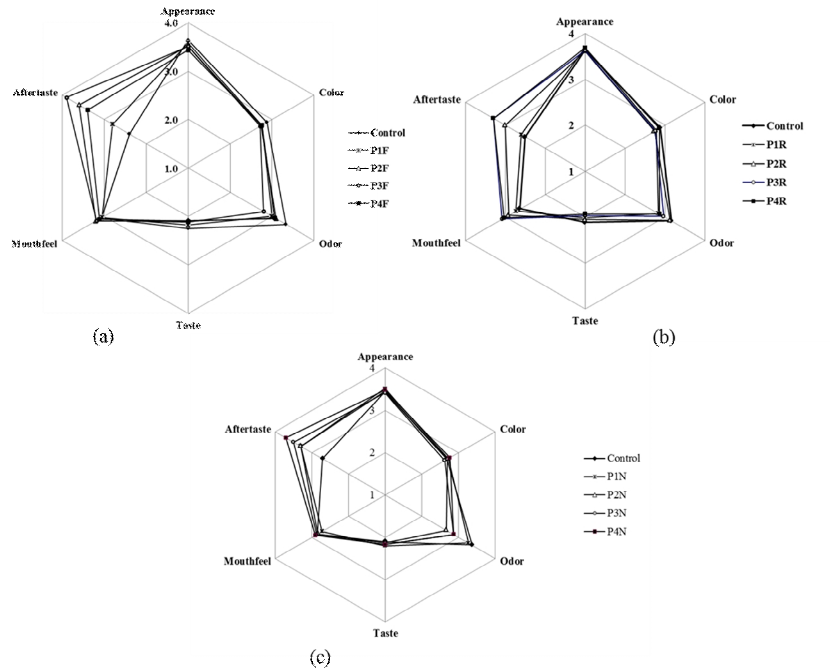

Figure 4. Comparative analysis of sensory profile of mincemeat compositions
a) mincemeat with sunflower oil (F); b) mincemeat with canola oil (R); c) mincemeat with walnuts oil (N)

The *mouthfeel* was rated with medium scores and average values of 3.05-3.20 were obtained for samples with sunflower oil. Because of the retention of the particles on the teeth, the samples with walnuts oil received lower appreciation for, being rated between 2.73 and 3.03. The lowest score (2.73) was given to the sample 1, and sample 3 received higher appreciation (3.08).

Some researchers reported that the inclusion of fibers in meat products increased hardness (Fernandez-Gines *et al.*, 2004). Huge reduction in the amount of fat leads to the rejection of products by the consumers (Tan *et al.*, 2006).

The *aftertaste* was better appreciated for samples with oil than control, in Figure 4 it can be seen that the control sample had obtained the lowest notes, by 25-30% lower when compared to samples with the largest amount of oil incorporated. The average values for the samples with sunflower oil were between 2.80-3.90, with maximum for samples 3 and minimum for samples 1. High values have been obtained for the samples with walnuts oil, between 3.30 and 3.70.

Values for the samples with canola oil were more homogenous, ranging between 3.30-3.70, with a maximum for the sample 4 (pork fat replaced of 85%).

Overall assessment of the sensory qualities of meat composition was below 3, in particular 2.86 for meat composition with sunflower oil, 2.82 for the composition of meat with canola oil and 2.75 for composition of meat with walnuts oil (Figure 5).

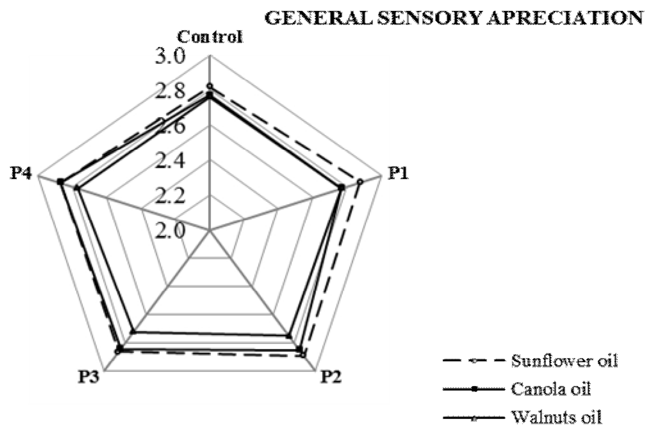

Figure 5. General appreciation of sensory profile of mincemeat compositions with low animal fat content

The score given to preferential test revealed that, out of the total of 10 panelists, six have preferred products with sunflower oil, and four have preferred products with canola oil, none chose products with walnut oil.

Overall salty taste (Figure 6) was well appreciated, being correlated with measurements which showed that salt levels did not exceed the permissible limit, ranging between 0.85 and 1.05%.

Conclusions

Analysis of color parameters L*, a* and b* led to the conclusion that the replacement of large quantities of fat in mincemeat compositions with different oils can produce color changes in the raw and finished products. Lightness (L*) of samples was not greatly influenced by the amount of oil added, its evolution is linear approximately. Instead, the parameters a* and b* were differentiated and correlated with the amount of fat replaced. Sunflower oil and canola oil decreased almost equally the degree of red (a*) for mincemeat with the increasing of added oil quantity. Samples with canola oil, which had more pronounced yellow tint that sunflower oil and walnuts oil, induced a sharp increasing of the parameter b* (degree of yellow). Samples with walnuts oil showed the lowest value of the intensity of degree of red (a*) for the P4 samples, giving them a more pronounced shade of green. Sunflower oil induced the fewest differences in color, but had lowest nutritional characteristics.

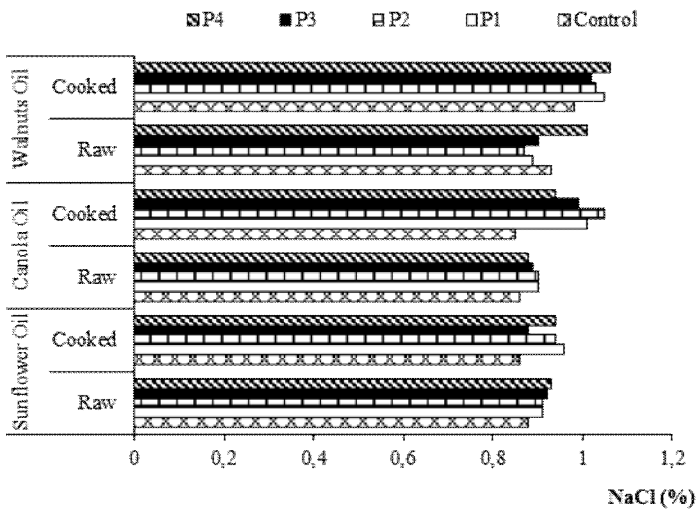

Figure 6. Mincemeats content of salt (%)

Products with sunflower oil were better accepted than those with canola oil and walnuts oil. General sensory appreciation led to the conclusion that the acceptance was medium for all cooked products. Aftertaste was favorable for the products with oils, the preferred ones being the samples with sunflower oil.

Color was better appreciated in the mincemeat with vegetable oil in compositions, particularly those in which it was replaced up to 60% of added animal fat with vegetal oils. These products were well accepted by consumers. It is important to educate the taste of the consumer to have greater acceptance for the products with vegetable oils, an important source of nutritional intake of ω-3 and ω-6 polyunsaturated fatty acids, the ratio in which they are found.

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