INFLUENCE OF TOMATO POWDER ON COMMINUTED MEAT PRODUCT QUALITY

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ABSTRACT

This study investigated the influence of tomato powder on the quality attributes (pH, colour, cooking loss, oxidative stability, sensory quality) of comminuted meat products. The addition of 2.0% and 2.5% of tomato powder significantly decreased lightness, increased redness and yellowness and delayed oxidation processes in the products. Tomato powder lowered the pH values of batters, but had no impact on pH or cooking losses of the products. Products enriched with tomato powder were more acceptable than the control sample. The results indicate the beneficial impact of tomato powder on the quality of comminuted meat products.

Keywords: functional foods, lipid oxidation, lycopene, meat product, sensory quality, tomato

1. INTRODUCTION

Tomatoes are valuable components of the human diet due to a high content of carotenoids, vitamins (C, K, E, B_1, B_2, B_5, B_6, PP, H) and mineral compounds (K, Na, P, Mg, Ca, Fe, Cu, Zn, Mn). Among the carotenoids, the most abundant is lycopene (FERNANDES *et al.*, 2016). Although fresh tomatoes are available on the market throughout the year, there are also many different processed tomato products offered to consumers, including ketchup, tomato puree (passata), concentrate, whole and cut canned tomatoes, sun-dried tomatoes and tomato powder. Although the processing of fruit and vegetables might reduce the concentration of valuable bioactive compounds, in the case of lycopene, thermal treatment of tomatoes increases lycopene concentration in the products from up to 4.2 mg/100 g in fresh tomatoes to up to 265 mg/100 g in tomato powder (SKIEPKO *et al.*, 2015). Tomato powder (TP) is produced from tomatoes subjected to drying and grinding, while lycopene itself might be obtained from waste material, such as tomato peel or seeds, or using chemical and microbial syntheses (HERNANDEZ-ALMANZA *et al.*, 2016).

A beneficial impact on human health has been attributed to lycopene consumption, due to its potential in alleviating chronic diseases, including cancer and coronary heart disease. Lycopene is recognized as a reactive oxygen species (ROS) scavenger and may therefore control ROS-mediated cell growth (HERNANDEZ-ALMANZA *et al.*, 2016; PALOZZA *et al.*, 2011). It has also been demonstrated that it induces cell-to-cell communication and improves the functioning of immune and hormone systems and may prevent osteoporosis (HERNANDEZ-ALMANZA *et al.*, 2016; SOŁTYSIAK and FOLWARCZNA, 2015). In order to induce a beneficial impact of lycopene on the human body, such as combating oxidative stress and adverting chronic diseases, from 5 to 10 mg of lycopene should be consumed daily (RAO and SHEN, 2002). The main sources of lycopene in the diet in Poland are fresh and processed tomatoes, tropical fruit and watermelons. The average daily lycopene intake in Poland is estimated at 7 to 7.5 mg, which is similar to levels noted for inhabitants of California (6.6 mg) and Canada (6.4 mg) (SOŁTYSIAK and FOLWARCZNA, 2015). Although the intake of lycopene is higher than the minimum recommended level, an increase in its consumption (e.g. in meat products containing processed tomatoes) would be beneficial.

Incorporating lycopene into meat products has gained much interest among food scientists and in the meat industry. Numerous papers concerning the effect of lycopene addition on the quality of meat products have been published (CALVO *et al.*, 2008; EYLIER and OZTAN, 2011; GARCIA *et al.*, 2009; HAYES *et al.*, 2013). However, to the authors' knowledge there are few products with tomato powder available on the market. Although the influence of lycopene on meat product colour is well-documented, the sensory quality of the products depends strongly on the amount and the source of lycopene, the nature of the food matrix and its composition. The influence of lycopene on lipid oxidation in meat products during storage is not fully recognized due to various factors affecting the process, related to raw materials (composition, physical state, comminution degree), methods used in meat processing, storage conditions, the length of storage, etc. In a previous study by the authors, the effect of adding from 0.2 to 1.0% tomato powder to comminuted meat products stored under vacuum up to 14 days was investigated (MODZELEWSKA-KAPITUŁA, 2012). All products showed good sensory quality, but the addition of tomato powder did not retard lipid oxidation in meatloaves stored in vacuum packages. Since higher amounts of tomato powder were not used, the present study was undertaken to investigate the effect of adding 2.0% and 2.5% of tomato powder on the quality of comminuted meat products. Moreover, in contrast to the previous study, the products were stored under aerobic conditions in a refrigerator for up to seven days, which resembles the conditions under which the products might be stored in households after opening a vacuum package in which products might be distributed and the influence of tomato powder on fat oxidation was studied. Therefore, the aim of the present study was to investigate the effect of an increased amount of tomato powder (up to 2.5%) on comminuted meat product quality, including pH values, thiobarbituric acid reactive substances (TBARS), sensory quality and colour.

2. MATERIAL AND METHODS

2.1. Materials and production

The meatloaves were produced from pork neck, which was ground twice through a size 5 mesh and mixed manually in a bowl with ice water (10%), bread crumbs (4%), fried onion (3%), an egg, salt (1.5%), pepper (0.1%), nutmeg (0.1%) and fresh garlic (0.07%). The amount of additives was calculated in respect to the mass of comminuted meat. Three treatments were produced: control – with no addition of tomato powder (TP) and with 2.0% and 2.5% of TP (ALTOMA 9010, Diana Naturals, Antrain, France, kindly provided by Kaczmarek-Komponenty, Mrowino, Poland). TP was added to a batter in the required amount and mixed manually to obtain an even distribution within the product. The batters (ca. 300 g) were placed in the individual aluminium forms and heated at 180°C in dry air to 72°C in a geometric centre. After thermal processing, products were cooled to 4°C±1°C and stored in darkness under aerobic conditions at 4°C±1°C until the 7th day after production. Three independent batches of meatloaves were produced on three different occasions.
According to the technical data sheet provided by the producer, the TP contained dehydrated tomato (*Lycopersicum esculentum L.*, min. 99% dry matter) and anti-caking agent: silicon dioxide (E551). It was a powder (100% < 1 mm) showing a medium solubility in water and red colour. Total carotenoid content, expressed as lycopene equivalent (EC Dir 95/45: OD 472 nm E 1%, 1 cm = 3,450, hexane) > 850 mg/kg, fresh tomato ratio: 17:1 (w/w). Indicative nutritional data for 100 g of TP were as follows: carbohydrates from 45.0 g to 75.0 g, fat up to 1.0 g, proteins (N × 6.25) from 5 g to 15 g, minerals from 2.0 g to 4.0 g, energy from 200 kcal to 370 kcal.

2.2. Methods

The following analyses were conducted: sensory evaluation (at day 1, the next day after production), pH measurements (day 1, 3, 7), colour evaluation (day 1) and TBARS (day 1, 3, 7).
Cooking loss was calculated based on the differences in the mass of the products before and after thermal treatment.
Acidity (pH) values were determined in batters and products (day 1, 3, 7) in homogenates prepared with 10 g of a batter or a product and 10 g of distilled water (pH-meter HI 8314C, Hanna Instruments Polska, Olsztyn, Poland). Three homogenates were prepared for each sample.
The 2-thiobarbituric acid reactive substances (TBARS), as an indicator of fat oxidation in products, were determined according to the modified Salih method (PIKUL *et al.*, 1993;

described in detail in MODZELEWSKA-KAPITUŁA, 2012) at day 1, 3 and 7. Two replicates from each sample were prepared.
The colour (CIE Lab) of the meatloaves was determined at day 1, using Miniscan XE Plus (HunterLab, Reston, USA) in three different positions on the surface and the cross-section of the products.
Sensory evaluation was conducted by six panellists trained and experienced in sensory evaluation, using difference and preference tests (scoring and ranking methods, respectively). The following attributes of the products were scored on a 6-point scale: overall appearance (1 – irregular shape, surface extremely dry or wet; 6 – regular shape, surface dry and clean), colour on the cross-section (1 – extremely pale, atypical, uneven; 6 – uniform, desirable), consistency (1 – extremely greasy, crumbling; 6 – compact, elastic), taste (1 – bland or extremely intensive, atypical; 6 – perceptible, typical), aroma (1 – bland or extremely intensive, atypical; 6 – perceptible, typical). The panellists were then asked to rank the products according to their preferences from the most desirable (value of 1) to the least desirable (value of 3). The samples for evaluation were served sliced (5 mm thick) at a temperature of approx. 10°C, randomly presented on white plates, coded with two-digit, random numbers. Water at room temperature and bread were provided for cleansing the palate between samples. The evaluation was carried out at room temperature (approx. 20°C) under fluorescent lighting. In total, three sensory analysis sessions were performed, during which three meat product samples were assessed per session.

2.3. Statistical analysis

The results were analysed using Statistica 12 (StatSoft. Inc., Tulsa, USA) at a significance level $p < 0.05$. The influence of tomato powder addition on colour, cooking loss and batter pH were evaluated using one-way variance analysis, as well as the influence of storage time on pH and TBARS. The results of sensory evaluations were analysed using a non-parametric Kruskal-Wallis test, whereas the results of a preference test were analysed using χ^2 Pearson's test.

3. RESULTS AND DISCUSSION

The influence of TP addition on pH and cooking loss of products is presented in Table 1. The addition of TP significantly lowered the pH values of the batters, which was caused by acidic pH of tomatoes. TP had no impact on the pH of final products or cooking losses. The pH values of products with and without TP addition did not change during 7- day storage in a refrigerator ($P<0.05$).
Reduction in pH values as a result of tomato products, such as dried tomato peel, sun-dried tomatoes and tomato paste, when added to meat products was reported also by other authors (CONDOGAN, 2002; GARCÍA *et al.*, 2009; ØSTERLIE and LERFALL, 2005). Reduced pH values of meat batters might increase cooking losses due to reduced water holding capacity of meat proteins (HUFF-LONERGAN and LONERGAN, 2005). In the present study, the decrease in pH values was apparently too low to exert an adverse effect on cooking loss.

Table 1. The influence of tomato powder (TP) on pH and cooking loss of comminuted meat products.

Attribute	Product		
	0% TP	2.0% TP	2.5% TP
pH: batter	6.1±0.1 [a]	5.9±0.1 [b]	5.7±0.1 [b]
pH: product day 1	6.8±0.2 [aA]	6.6±0.2 [aA]	6.5±0.2 [aA]
pH: product day 3	6.8±0.2 [aA]	6.6±0.2 [aA]	6.5±0.2 [aA]
pH: product day 7	6.8±0.1 [aA]	6.6±0.1 [aA]	6.5±0.1 [aA]
Cooking loss (%)	8.0±0.1 [a]	8.5±0.1 [a]	8.9±0.1 [a]

[a,b] means in rows with different letters differ significantly at $p < 0.05$; [A] means in columns with the same letter do not differ significantly at $p < 0.05$.

The colour of the surface and the cross-section of the products containing TP and those without the ingredient differed significantly and, moreover, the amount of TP affected the intensity of the cross-section colour (Table 2). The surface of the control samples (0% TP) had higher L* and lower a* and b* values than TP-containing products (2.0% TP and 2.5% TP). A cross-section of the control sample also had higher L* values than both TP-containing samples. The values of a* and b* increased with the increase in TP addition, which indicates that when more TP was added to the batter, the cross-section colour of the products became more intense and the proportion of red and yellow hues was higher and, thus, the colour turned toward orange. These results resemble those presented by GARCÍA *et al.* (2009), EYILER and OZTAN (2011), HAYES *et al.* (2013).

Table 2. The influence of tomato powder (TP) on the colour and sensory attributes of comminuted meat products.

Attribute	Product		
	0% TP	2.0% TP	2.5% TP
Colour: surface			
L*	43.5±5.3 [a]	23.6±1.9 [b]	35.2±4.5 [b]
a*	7.4±1.5 [b]	15.8±0.8 [a]	15.7±1.5 [a]
b*	19.6±3.4 [b]	23.4±1.7 [a]	22.2±2.5 [a]
Colour: cross-section			
L*	59.6±5.4 [a]	53.5±3.8 [b]	53.5±2.8 [b]
a*	5.4±0.8 [c]	13.8±2.3 [b]	16.7±1.3 [a]
b*	17.8±0.7 [c]	23.6±1.7 [b]	26.7±0.7 [a]
Sensory quality			
Overall appearance	3.9±1.1 [a]	4.4±1.1 [a]	4.4±0.9 [a]
Colour of the cross-section	4.0±1.2 [a]	4.3±1.0 [a]	3.8±1.0 [a]
Consistency	4.6±0.9 [a]	4.5±1.1 [a]	4.3±1.0 [a]
Taste	4.4±1.1 [a]	4.8±1.2 [a]	4.7±1.2 [a]
Aroma	4.5±1.2 [a]	4.3±0.9 [a]	4.2±1.0 [a]

[a,b,c] means in rows with different letters differ significantly at $p < 0.05$.

Sensory analysis comprised the evaluation of particular attributes of products (Table 2) and the indication of the most preferred product. All products were scored between 3.8 and 4.8, which indicated their good sensorial quality and there were no significant differences between the control and TP containing products. These results are in line with those of GARCÍA *et al.* (2009), who used dry tomato peel (DTP) in hamburgers and noted no significant differences between the control sample and those produced with a 3% addition of DTP in odour and texture. CALVO *et al.* (2008) also reported no differences in a hedonic test of dry fermented sausages produced with dry tomato peel up to 1.2% (w/w). Panellists more often chose products with TP (2.0% and 2.5%) as more preferred than the control (0% TP) ($P<0.05$). The results indicate that a TP addition in the range from 2.0% to 2.5% positively affected the sensory quality of comminuted meat products. CALVO *et al.* (2008) found that the colour of meat products (sausages) influenced the preferences of consumers, although in their study the addition of dry tomato peel (0.9 and 1.2%) to sausages lowered their acceptability. Thus, it might also be concluded that the acceptability of meat products with tomato powder depends on the product type and its characteristics.

Tomato powder affected TBARS in the products during 7-day cold storage in aerobic conditions (Fig. 1). In the control sample, which did not contain TP, TBARS increased in storage time and significant differences between day 1, day 3 and day 7 were noted ($P<0.05$). In the product, which contained 2.0%, TBARS increased between day 1 and 3 and remained unchanged between day 3 and 7, whereas in the product (which contained 2.5% TP) TBARS did not change during the storage period.

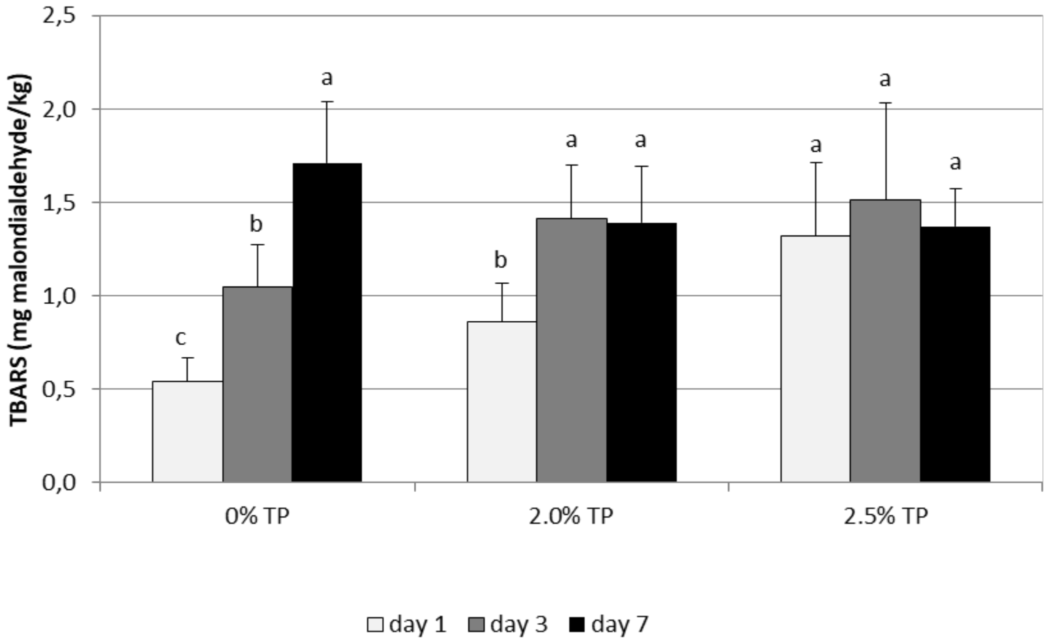

Figure 1. The influence of storage time on TBARS in meatloaves produced with the addition of tomato powder (2.0% TP, 2.5% TP) and without the tomato powder (0% TP).

[a,b,c] means within each treatment with different letters differ significantly at $p < 0.05$.

These findings suggest that tomato powder has the potential to inhibit oxidation in meat products stored under aerobic conditions and its effectiveness depends on the amount of tomato powder. The anti-oxidative effect of lycopene added to paprika salami was also reported by ROHLÍK *et al.* (2013), which supports the results of the present study. On the other hand, it was also noted that TBARS values at day 1 were the highest for 2.5% TP, whereas they were the lowest for 0% TP products. The results indicate that the method used for TBARS determination, which is suitable for evaluation of the oxidation process in meat and meat products, might give misleading results, probably due to the elution of carotenoids from TP-containing samples, which contributes to higher absorbance values. That is why the results of TBARS were not compared between samples containing different amounts of TP, but analysed taking into consideration only the storage time. On the other hand, the increase in TBARS along with the increased amount of tomato products (powder, paste) in meat products was also noted by EYILER and OZTAN (2011), DEDA *et al.* (2007) and HAYES *et al.* (2013), who attributed it to the pro-oxidative effect of lycopene used in higher concentrations.
TBARS is used as a lipid oxidation indictor in meat and processed meat products. A threshold of 2 mg malondialdehyde/kg sample is regarded as the minimum TBARS value that causes the off-flavour in meat and meat products (EYILER and OZTAN, 2011). No samples investigated in this study exceeded 2 mg MA/kg during seven days of storage under aerobic conditions, which indicated that their quality was not reduced by excessive lipid oxidation. Similar values were noted in the previous studies, in which meat products with lycopene addition were stored vacuum-packed (MODZELEWSKA-KAPITUŁA, 2012; EYILER and OZTAN, 2011). However, in the previous studies, the antioxidant properties of lycopene in cooked meat products, stored in vacuum-packages were not proven, probably due to evacuation of the oxygen from vacuum packages.

4. CONCLUSIONS

In conclusion, tomato powder added in amounts of 2.0% and 2.5% to a comminuted meat product increased its sensory acceptability and oxidative stability, changed the colour towards more orange and decreased pH, although it had no influence on cooking losses. Thus, the meat products obtained using 2.5% of tomato powder might be a healthier alternative to the ready-to-eat meat products currently available on the market. However, before launching them on the market, the results of the present study should be complemented with an evaluation of consumer acceptability of the products and determination of microbial quality, due to the lack of preservatives such as sodium nitrite. Lycopene content in the products should also be examined, since the storage of tomato products (e.g. tomato puree) might reduce lycopene content (MARKOVIĆ *et al.*, 2007). The application of tomato powder as a source of lycopene and the lack of food additives provides the opportunity to introduce "clean label" products with nutritional benefits for the consumer.

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