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INSTRUMENTAL COLOUR AND TEXTURE PROPERTIES OF FRANKFURTER-TYPE SAUSAGES WITH PLANT OILS

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Abstract: The aim of this research was to examine the influence of partial and total replacement of pork backfat with two quite different (in terms of sensory properties) plant oils (grapeseed and pumpkinseed oil) on instrumental colour and texture of frankfurters. The influence on colour was more pronounced when pumpkinseed oil emulsion was used as backfat replacer – these frankfurters were less red and more yellow than control and frankfurters with grapeseed oil emulsion. The effect was more pronounced with the increase of backfat replacement degree. No significant influence on instrumental texture parameters was observed.

Keywords: frankfurters, grapeseed oil, pumpkinseed oil, colour, texture

Introduction

Meat products lost their primary function in the last 50–60 years – to preserve meat and provide energy, proteins of high biological value and minerals, so thay are nowadays highly valued mainly because of their sensory properties. However, some components of meat products such salt, phosphates, nitrites, fat, saturated fatty acids etc., are mentioned as having a negative impact on human health. High daily intake of animal fat rich in saturated fatty acids (SFA) is associated with a higher risk of cardiovascular diseases (McAfee et al., 2010).

Emulsion-type meat products such as hot-dogs and frankfurters are well-known worldwide and together with burgers/patties represent a hallmark of the fast-food industry. Total fat content in emulsion-type meat products is usually within interval 20–30% (Pisinov et al., 2021). Fat is very important because it contributes to the physical and chemical stability of the product – fat stabilizes the meat emulsion, reduces cooking loss, increases the ability to retain water, and greatly affects the colour and juiciness (Câmara and Pollonio, 2015).

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Reduction of fat content significantly altered technological and sensory properties of emulsion-type meat products (Cengiz and Gokoglu, 2007). In view of this, only a partial fat reduction and/or replacement can be done. The two strategies have been established to achieve this (Kurćubić et al., 2022): i) partial decrease of fatty tissue and/or replacement with non-lipid replacers and ii) partial fatty tissue replacement with oils rich in polyunsaturated fatty acids (PUFA).

Regarding emulsion-type meat products several research studies were successfully conducted with the aim of replacing fatty tissue with non-lipid replacers (Bajcic et al., 2023; Kurćubić et al., 2020). Also, fatty tissue was partially replaced with oils to obtain a favourable fatty acids profile (Stajić et al., 2020; Stajić et al., 2018). The research data indicate that the impact of partial fatty tissue replacement with oils on properties of meat products depends on oil properties, level of replacement, oil stabilization procedure and type of meat product (Stajić and Živković, 2021). While refined grapeseed oil is very light and has a neutral odour and taste, pumpkin oil is darker and has a specific odour and taste (Stajić et al., 2020; Stajić et al., 2014). Firstly, oils were stabilized in emulsion with soy protein isolates (commonly used ingredient in meat processing). Later, gel emulsions, double emulsions, oleogels etc. were used for oil stabilization (Stajić and Vasilev, 2022).

The aim of this research, which is a follow-up on the research conducted by Stajić and Živković (2021), was to examine the influence of partial and total replacement of pork backfat with two plant oils (grapeseed and pumpkinseed oil), quite different in sensory properties, on instrumental colour and texture of frankfurters.

Materials and methods

Frankfurters were prepared in the same manner as described by Stajić and Živković (2021). Control treatment (CON) was prepared with beef, pork backfat and ice in the ratio of 50:25:25. Six modified treatments were prepared by replacing 20%, 60% and 100% of backfat with emulsions of grapeseed oil (GSO20, GSO60 and GSO100, respectively) and pumpkinseed oil (PSO20, PSO60 and PSO100, respectively). All treatments were prepared in the same manner. Beef and backfat were initially ground trough a 10 mm plate. Afterwards, beef was mixed and ground with ice, salt and phosphates in the cutter (knife and bowl speed 1,410 and 12 rpm, respectively) for 2 min. Then, pork backfat, oil emulsion (for modified treatments) and other ingredients were added and emulsified (knife

and bowl speed 2,780 and 24 rpm, respectively) until the temperature of 14 °C was achieved. Frankfurters were stuffed into collagen casings, (diameter 22 mm and 50 g approximate weight) and underwent the following regime in a smoking/cooking chamber: drying 10 min at 50 °C, smoking 30 min at 60 °C, and heated at 85°C until the temperature in the center of the product reached 70 °C. Afterwards, the frankfurters were showered with warm water (about 50 °C) for 15 min and cooled in a cooling chamber at 3±1 °C overnight. Emulsions of vegetable oils were prepared immediately before frankfurter preparation in the manner described by Stajić et al. (2014): 5 parts of water were mixed with one part of soy protein isolate (SUPRO EX 33 IP, Solae, LLC) in a cutter for two minutes, then five parts of cooled oil was added and mixing was continued for 3 to 5 minutes until the emulsion became compact and stable.

The CIE L*a*b* colour coordinates were determined by MINOLTA Chroma Meter CR-400 (Minolta Co., Ltd., Osaka, Japan) using an 8-mm aperture size, illuminant D65 and a 2° standard observer angle. The Chroma Meter was calibrated using a Minolta calibration plate (No. 11333090; Y = 92.9, x = 0.3159; y = 0.3322). C* (chroma) and h (hue angle) were calculated using software Konica Minolta Color Data Software CM-S100w Spectra Magictm NX Pro QC ver. 2.0. Two measurements on four frankfurters of each treatment were taken (n=8).

Total colour difference (TCD) relative to CON was calculated using the standard equation:

$$TCD = \sqrt{(L^*_{MT} - L^*_{CON})^2 + (a^*_{MT} - a^*_{CON})^2 + (b^*_{MT} - b^*_{CON})^2}$$

MT – modified treatments; CON – control

Texture profile analysis was performed using the universal texture analyser TAXP (Stable Micro System, Godalming, UK). Samples for texture analysis were cylindrical, 2 cm in height and original diameter. The samples were compressed twice to 40% of their original height, with a compression aluminium platen of 75 mm (P/75) and constant test speed of 1 mm s^{-1}. Hardness, springiness, cohesiveness and chewiness were evaluated and were obtained using the available computer software. Eight readings were taken for each treatment (four frankfurters with two samples from each).

One-way ANOVA was performed for testing the influence of backfat replacement. Tukey's HSD test was used to identify significant ($p < 0.05$) differences between treatments. Statistical analysis was performed with software Statistica 12.5 PL, for Windows (StatSoft, Inc., Tulsa, OK, USA).

Results and discussion

The replacement of backfat with oil emulsions had a significant influence on all parameters of instrumental colour (Table 1). The effects are dependent on replacement degree and oil type. Lightness (L* values) was more altered when backfat has been replaced with grapeseed oil emulsion. Also, progressive increase of L* values was observed with the increasing content of grapeseed oil emulsion. However, no significant difference ($p > 0.05$) was observed between GSO60 and GSO100. This was not observed when pumpkinseed oil emulsion was used as backfat replacer – PSO60 and PSO100 had similar L* values to control ($p > 0.05$).

Table 1. Results of instrumental colour analysis of cross section

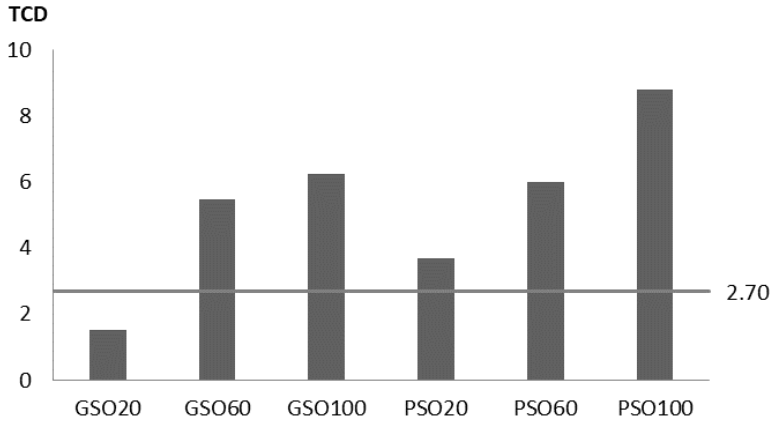
	L*	a*	b*	C*	h
CON	62.62±0.60c	16.71±0.45a	13.65±0.22d	21.55±0.44b	39.27±0.54f
GSO20	63.91±0.40b	16.40±0.30a	13.99±0.30d	21.55±0.39b	40.50±0.47f
GSO60	67.86±0.48a	15.12±0.33b	13.92±0.20d	20.54±0.33c	42.69±0.51e
GSO100	68.37±0.67a	14.33±0.37c	13.93±0.33d	19.99±0.22c	44.20±1.25d
PSO20	64.63±0.70b	14.64±0.61bc	15.77±0.27c	21.53±0.29b	47.20±1.61c
PSO60	62.81±0.52c	12.62±0.58d	17.91±0.27b	21.89±0.48b	54.91±1.10b
PSO100	62.87±0.44c	10.75±0.39e	20.07±0.37a	22.77±0.44a	61.89±0.77a

CON – control treatment; CON – control treatment; GSO20 & PSO20 – 20% backfat replaced with grapeseed oil emulsion and pumpkinseed oil emulsion respectively; GSO60 & PSO60 – backfat replaced with grapeseed oil emulsion and pumpkinseed oil emulsion respectively; GSO100 & PSO100 – 100% backfat replaced with grapeseed oil emulsion and pumpkinseed oil emulsion respectively; a–f Values (mean±SD) in the same column with different letters are significantly different ($p<0.05$)

Regarding redness (a* values), only GSO20 had similar values to CON, while in other treatments a* values were progressively and significantly lower with the increase of backfat substitution level. Yellow tones (b* and h values) progressively and significantly ($p < 0.05$) increased with pumpkinseed oil emulsion content. In GSO treatments b* values were similar ($p > 0.05$) to CON, while hue angle values progressively increase with grapeseed oil emulsion level. However, the effect was more pronounced in frankfurters with pumpkinseed oil emulsion as backfat replacer.

Chroma values had the opposite trend regarding the oil added – they decreased when grapeseed oil emulsion was used and increased when pumpkinseed oil emulsion was used while significant differences were

observed in treatments with total backfat replacement with oil emulsions. These very intense changes of colour properties in frankfurters with pumpkinseed oil emulsions could influence sensory acceptability which was confirmed in a previous research by Stajić and Živković (2021) – frankfurters with 60% and 100% backfat replacement had significantly lower grades regarding colour compared to control and all GSO treatments. On the other hand, all GSO treatments received similar grades to control treatment. Stajić et al. (2020) also reported significantly higher b* and h* values when 25% of backfat was replaced with encapsulated pumpkinseed oil. Regarding the use of grapeseed oil, according to Stajić et al. (2014), the influence on colour properties is more dependent on the oil stabilization procedure than oil colour properties.



Graph 1. TCD values of modified frankfurter compared to CON; Horizontal line indicates potential visual detection limit

Total colour difference (TCD) represents the quantification of the overall difference between two colours – e.g. modified treatments vs CON. Research indicates that TCD values less than 2.7 were probably not perceptible by consumers. TCD values (Graph 1) of all modified frankfurters, except GSO20 were higher than 2.7 and progressively increased with oil emulsion content. The effect was more pronounced when pumpkinseed oil emulsion was used as backfat replacer.

In general, it could be said that backfat replacement with oil emulsion led to lower hardness and chewiness. However, all parameters of instrumental texture were not significantly affected by the level of backfat replacement (Table 2).

Table 2. Results of texture profile analysis (TPA)

	Hardness (g)	Springiness	Cohesiveness	Chewiness (g)
CON	4537.27±976.20a	0.83±0.08a	0.84±0.02a	3203.67±897.81a
GSO20	3921.05±479.15a	0.83±0.04a	0.81±0.02a	2660.28±382.56a
GSO60	3873.99±492.63a	0.81±0.08a	0.82±0.01a	2586.96±401.82a
GSO100	3802.09±661.68a	0.86±0.06a	0.83±0.02a	2711.95±473.83a
PSO20	4039.64±570.42a	0.84±0.05a	0.80±0.01a	2720.33±505.02a
PSO60	4041.08±204.82a	0.83±0.04a	0.83±0.02a	2780.41±189.54a
PSO100	4217.14±697.53a	0.86±0.07a	0.81±0.07a	2920.98±508.96a

CON – control treatment; GSO20 & PSO20 – 20% backfat replaced with grapeseed oil emulsion and pumpkinseed oil emulsion respectively; GSO60 & PSO60 – backfat replaced with grapeseed oil emulsion and pumpkinseed oil emulsion respectively; GSO100 & PSO100 – 100% backfat replaced with grapeseed oil emulsion and pumpkinseed oil emulsion respectively; Values (mean±SD) in the same column with different letters are significantly different ($p<0.05$)

Conclusion

The results of this research indicate that oil properties should not be ignored in the creation of emulsion-type meat products with improved nutritional properties. In order to reduce the impact of emulsion-type meat products on colour, the level of backfat replacement should be adjusted to colour properties of the oil added.

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