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EFFECT OF PARAMETERS OF THERMAL PROCESS ON THE PROPERTIES OF PEANUTS

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Key words: roasting, deep-frying, microwaving, peanuts, sensory and physicochemical properties

The objective of this study was comparing physical-chemical, and organoleptic properties of peanuts roasted in hot air – with and without air flow, deep-fried in oil and treated in microwave.

It has been stated that peanut properties depended on the method of thermal processing and parameters applied. As the temperature increased, air flow speed, power (regardless the method) and moisture show decreased values. Nuts deep-fried in oil were characterised by higher fat content as compared to the ones roasted in hot air or treated in microwave. The method and parameters of thermal processing effected on the properties of peanut fat fraction – acid value remained unchanged, while peroxide value underwent alterations according to the temperature. Peanut colour, alike, proved to be effected by thermal processing – the higher temperature the darker peanut colour. The most considerable alterations were recorded for peanuts deep-fried in oil and roasted with the use of dry method, *i.e.* hot air follow of the temperature ranging 170°C and 180°C. The method of roasting influenced also peanut texture – the most delicate nuts were obtained when deep-fried in oil and roasting in a roaster with air flow, while the hardest ones resulted from dry method without air flow. The most advantageous organoleptic properties, regardless the methods, featured the peanuts thermal processed at the temperature of 140°C.

INTRODUCTION

Roasted peanuts have become a popular snack product and a valuable addition to different kinds of confectionery and bakery products. They owe their popularity first of all to the properties they acquire in the course of roasting – attractive colour, characteristic taste and smell, as well as crispy and delicate texture [Bucholz *et al.,* 1980]. As a result of Maillard reaction, there are formed colorants, also responsible for the typical odour of roasted peanuts [Saklar *et al.*, 2001]. There can be recorded a decrease in peanuts water content as well, which is connected with structural alterations directly effecting texture of a ready product [Demir & Cronin, 2004; Saklar *et al.*, 2003]. Because of the conditions of roasting, and first of all, the temperature usually ranging 100-180°C, there can also be detected disadvantageous alterations in the course of roasting – mainly in peanut fat fraction [Bolton & Sanders, 2002]. Peanuts contain 50% of fat composed mostly of unsaturated fatty acids – the components especially susceptible to thermooxidative alterations [Slade & Levine, 2006; Yoshida *et al.*, 2005]. Therefore, a careful combination of appropriate conditions of roasting, depending on the method applied, has become a considerable problem.

Peanuts are usually roasted in hot oil (deep-fried) or air [Perren & Escher, 1997]. Different time and temperature of roasting are strictly connected with the kind of heating medium. In some countries (*e.g.* Japan) introduction of microwave treatment, often conducted in home conditions, has become more and more popular [Yoshida *et al.,* 2003]. Therefore the aim of the research was to compare physicochemical and organoleptic properties of peanuts roasted in hot air – with and without air flow, deep-fried in oil and treated in a microwave.

MATERIALS AND METHODS

Materials. The material consisted of shelled raw peanuts (produced in China) bought from a local distributor. Samples (200 g) of peanuts halves (initial moisture 5.3%) were roasted in hot air (laboratory dryer, Poland) and (laboratory roaster, Poland), deep-fried in rapeseed oil (electric fryer, Beckman, Italy), and treated using microwaves (Whirpool). Peanuts were thermally processed at 100-180°C for 17 min (dry roasting and deep-frying). The air velocity in the roaster was 3.4 m/s. Microwave treatment was conducted using three levels of power: 500, 750 and 1000 W. After processing peanuts were packed in plastic bags and taken to a laboratory for analyses. The data are mean results obtained in three technological replications.

Analysis. Peanuts moisture content was determined using the gravimetric method. Fat content of peanuts was measured according to Soxhlet's method. Fat was extracted using a Büchi B-811 Universal Extraction System (Büchi Labortechnic AG, Flawil, Switzerland). Two grams of sample were extracted for 180 min using diethyl ether as a solvent

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[AOAC, 1995]. Fatty acid composition of fat was analysed using gas chromatography. Peroxide value (PV) and free fatty acids (FFA) content were determined in fat fraction of roasted peanuts according to AOAC standards.

Peanuts texture was determined using an Instron Model 5544 Universal Texture Analyser outfitted with an extensometer head of the range up to 2 kN. Single peanut halves were compressed between two parallel plates at the speed of 5 mm/min. The test lasted until the examined sample was damaged and enabled determining the maximum compressive force Fc_{max}. Each measurement was conducted on 10 nut halves [Kita & Figiel, 2006].

The colour of peanuts was measured with the use of a Minolta Chroma Meter CR-200 Reflectance system. The measurements were conducted after milling peanuts to constant grind size on 10 nuts samples from all roasting conditions [Özdemir & Devres, 2000].

Organoleptic qualities – colour, flavour, odour and texture were assessed according to a five-grade scale (5 points – the best, 1 point – the worst). A panel of 10 panelists, ages 23-25 years (all students of the Faculty of Food Science), with sensory evaluation experience, was trained in descriptive evaluation of nuts.

Statistical analysis. The data were analysed statistically using Statistica 6 programme (2001). For comparison, the results obtained underwent a one-way analysis of variance with the application of Duncan's test ($p \leq 0.05$). To assess rank variables (organoleptic nuts evaluation on the 1-5 scale), the non-parametric Kruskal-Wallis test was used. Homogenous groups were shaped on the basis of the determined ranks.

RESULTS AND DISCUSSION

Raw peanuts feature typical fat content and its properties (Table 1). Thermal processing effected on the decrease in moisture of all the analysed peanuts samples (Figure 1). More considerable moisture alterations took place in the course of roasting in a roaster in comparison to deep-frying in oil or with the use of a dryer. All samples processed using the microwave method were characterised by low moisture (<0.5%). Similar dependencies were reported by other authors who analysed peanuts roasted according to different methods [Adebiyi *et al*., 2002].

Alterations in fat content of peanuts deep-fried in oil were shown in Figure 2. As temperature increased the nuts absorbed higher amounts of frying fat (maximum 4%). Table 2 shows alterations in fat fraction of peanuts thermal processed with different methods. Regardless the method and parameters applied, free fatty acids content ranged a similar level. Yet alterations affected peroxides content, which pointed to

TABLE 1. Chemical composition of fresh peanuts.

	Moisture content (%)	Fat content (%)	Main fatty acids (%)					PV (meq O_2/kg)	AV (mg KOH/g)
			C 16:0	C 18:0	C 18:1	C 18:2	C 18:3		
Fresh peanuts	5.30 ±0.16	50.20±0.34	11.71±0.23	3.49±0.08	42.61±0.39	35.44±0.34	0.09±0.01	0.87±0.12	10.20±0.73

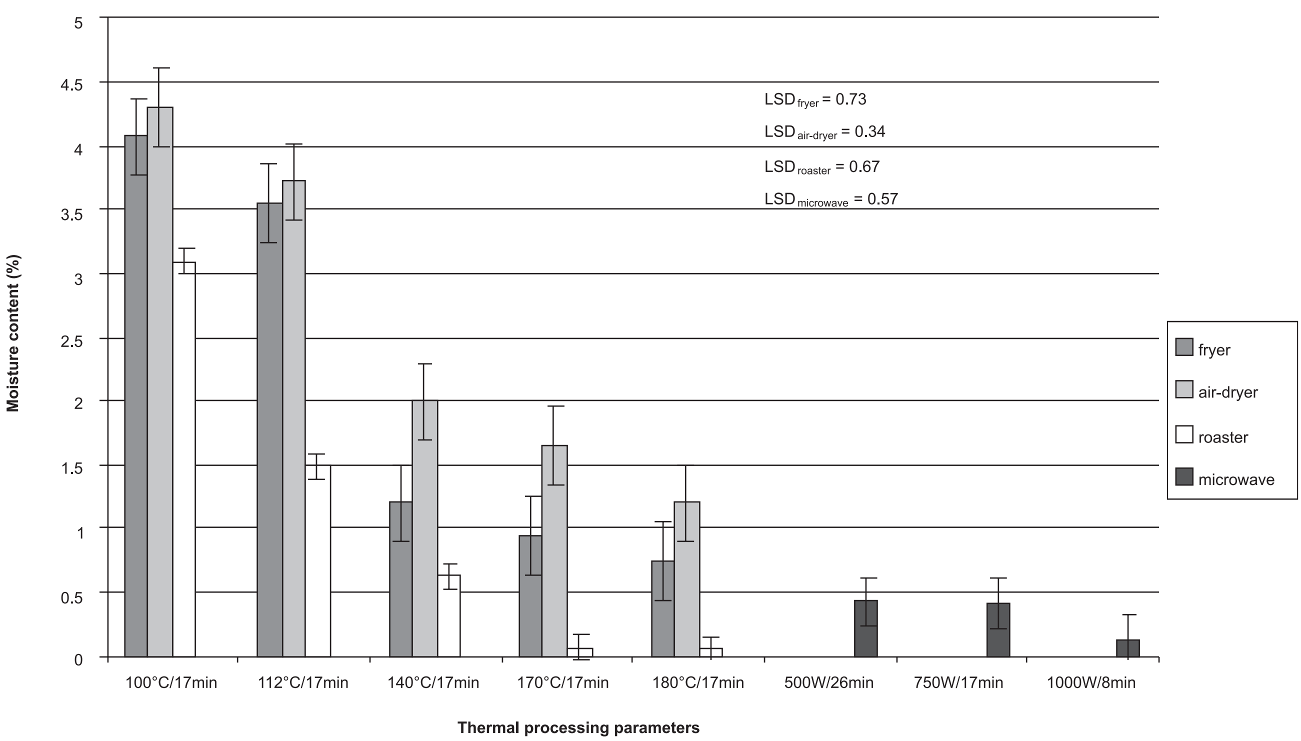

FIGURE 1. Moisture content of peanuts thermally-processed using different methods.

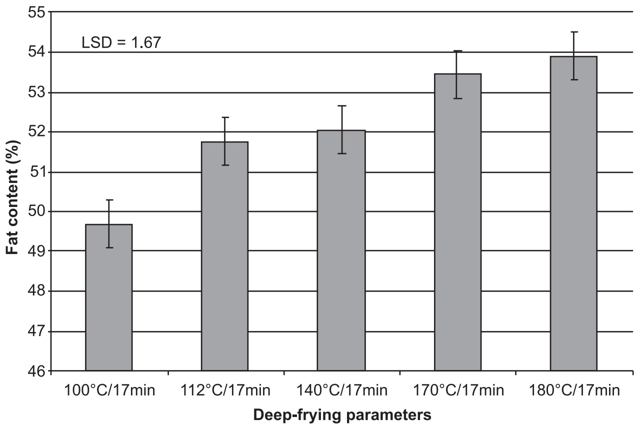

FIGURE 2. The fat uptake of peanuts deep-fried in oil.

the rate of oxidative changes. In peanuts roasted in air the amount of peroxides did increase as roasting temperature increased, while in peanuts deep-fried in oil at the temperatures of 170°C and 180°C there dominated reactions of peroxides decomposition which resulted in the decrease in peroxide number. In microwave processing higher peroxide content featured fat fraction of peanuts treated at higher microwave power applied. Yoshida *et al.* [2003], comparing the properties of microwave-treated peanuts, stated that at the same microwave power used peroxides content in the examined peanuts samples increased as processing time prolonged. The method and parameters of thermal processing also effected on fatty acids composition in peanuts – the lowest unsaturation ratio was typical of fat extracted from peanuts deep-fried in oil, while the highest one belonged to those processed in a microwave.

TABLE 2. Acid value, peroxide value and unsaturation ratio (C18:2/C16:0) of fat extracted from thermally-processed peanuts.

Type of equipment	Parameters of thermal processing	Acid value (mg KOH/g)	Peroxide value (meq O_2/kg)	Unsaturation ratio (C18:2/C16:0)
Fryer	100°C/17min	7.76 ± 0.13^{aA}	1.09 ± 0.05^{aA}	1.98
	112°C/17min	8.13 ± 0.17^{aA}	14.09 ± 0.23^{cB}	2.03
	140°C/17min	8.75 ± 0.09^{aA}	10.09 ± 0.19^{bB}	2.04
	170°C/17min	7.32 ± 0.11^{aA}	2.25 ± 0.09^{aA}	2.32
	180°C/17min	7.61 ± 0.09^{aA}	0.18 ± 0.02^{aA}	2.21
Air-dryer	100°C/17min	10.00 ± 0.21^{aA}	0.28 ± 0.04^{aA}	2.76
	112°C/17min	9.10 ± 0.14^{aA}	0.55 ± 0.07^{aA}	2.44
	140°C/17min	9.45 ± 0.16^{aA}	6.96 ± 0.11^{bcA}	1.78
	170°C/17min	9.87 ± 0.16^{aA}	3.70 ± 0.09^{bA}	1.52
	180°C/17min	10.75 ± 0.20^{aA}	5.08 ± 0.14^{bC}	1.77
Roaster	100°C/17min	9.58 ± 0.19^{aA}	0.13 ± 0.02^{aA}	3.06
	112°C/17min	10.17 ± 0.22^{aA}	0.56 ± 0.03^{aA}	2.90
	140°C/17min	10.49 ± 0.21^{aA}	6.62 ± 0.15^{cA}	2.94
	170°C/17min	8.92 ± 0.17^{aA}	3.57 ± 0.08^{bA}	2.87
	180°C/17min	8.08 ± 0.15^{aA}	3.37 ± 0.09^{bB}	2.75
Microwave	500W/26min	10.78 ± 0.24^{a}	3.73 ± 0.09^{a}	2.94
	750W/17min	10.95 ±0.21^{a}	6.44 ± 0.16^{b}	3.11
	1000W/8min	11.00 ± 0.26^{a}	6.43 ± 0.17^{b}	3.15

Lower-case letters indicate significant differences between thermal process parameters in each method ($\alpha \leq 0.05$)
Capital letters indicate significant differences between peanuts thermal processed in fryer, air-dryer and roaster at the same parameters ($\alpha \leq 0.05$)

TABLE 3. Colour (L*a*b*) of thermally-processed peanuts.

Type of equipment	Parameters of thermal processing	L*	a*	b*
Fryer	100°C/17min	67.18 ± 0.17^{eAB}	-0.13 ± 0.01^{aB}	13.76 ± 0.14^{aB}
	112°C/17min	65.50 ± 0.21^{dB}	0.24 ± 0.01^{aB}	13.74 ± 0.15^{aB}
	140°C/17min	55.13 ± 0.19^{cA}	6.17 ± 0.12^{bC}	27.14 ± 0.19^{cC}
	170°C/17min	38.34 ± 0.16^{bA}	10.56 ± 0.19^{cB}	26.23 ± 0.21^{cB}
	180°C/17min	29.90 ± 0.18^{aA}	12.25 ± 0.21^{dC}	19.33 ± 0.18^{bA}
Air -dryer	100°C/17min	67.93 ± 0.15^{bB}	-0.71 ± 0.06^{aA}	11.69 ± 0.09^{aA}
	112°C/17min	67.03 ± 0.16^{bC}	– 0.45 ± 0.04^{aA}	12.01 ± 0.10^{aA}
	140°C/17min	66.12 ± 0.15^{bC}	0.55 ± 0.07^{bA}	16.43 ± 0.12^{bA}
	170°C/17min	59.31 ± 0.14^{aC}	2.25 ± 0.10^{cA}	22.37 ± 0.18^{cA}
	180°C/17min	59.41 ± 0.15^{aC}	5.82 ± 0.12^{dA}	29.05 ± 0.20^{dC}
Roaster	100°C/17min	62.46 ± 0.17^{eA}	-0.27 ± 0.01^{aB}	11.88 ± 0.09^{aA}
	112°C/17min	60.64 ± 0.15^{dA}	– 0.35 ± 0.01^{aA}	12.41 ± 0.11^{aA}
	140°C/17min	56.54 ± 0.14^{cB}	2.67 ± 0.11^{bB}	21.28 ± 0.13^{bB}
	170°C/17min	39.74 ± 0.13^{bB}	10.15 ± 0.15^{cB}	27.91 ± 0.18^{dC}
	180°C/17min	31.80 ± 0.14^{aB}	10.53 ± 0.14^{cB}	23.93 ± 0.16^{cB}
Microwave	500W/26min	59.32 ± 0.16^{c}	1.84 ± 0.09^{a}	18.77 ± 0.19^{a}
	750W/17min	46.14 ± 0.15^{a}	7.11 ± 0.12^{c}	25.00 ± 0.15^{b}
	1000W/8min	51.22 ± 0.16^{b}	5.33 ± 0.10^{b}	24.75 ± 0.14^{b}

Lower-case letters indicate significant differences between thermal process parameters in each method ($\alpha \leq 0.05$)
Capital letters indicate significant differences between peanuts thermal processed in fryer, air-dryer and roaster at the same parameters ($\alpha \leq 0.05$)

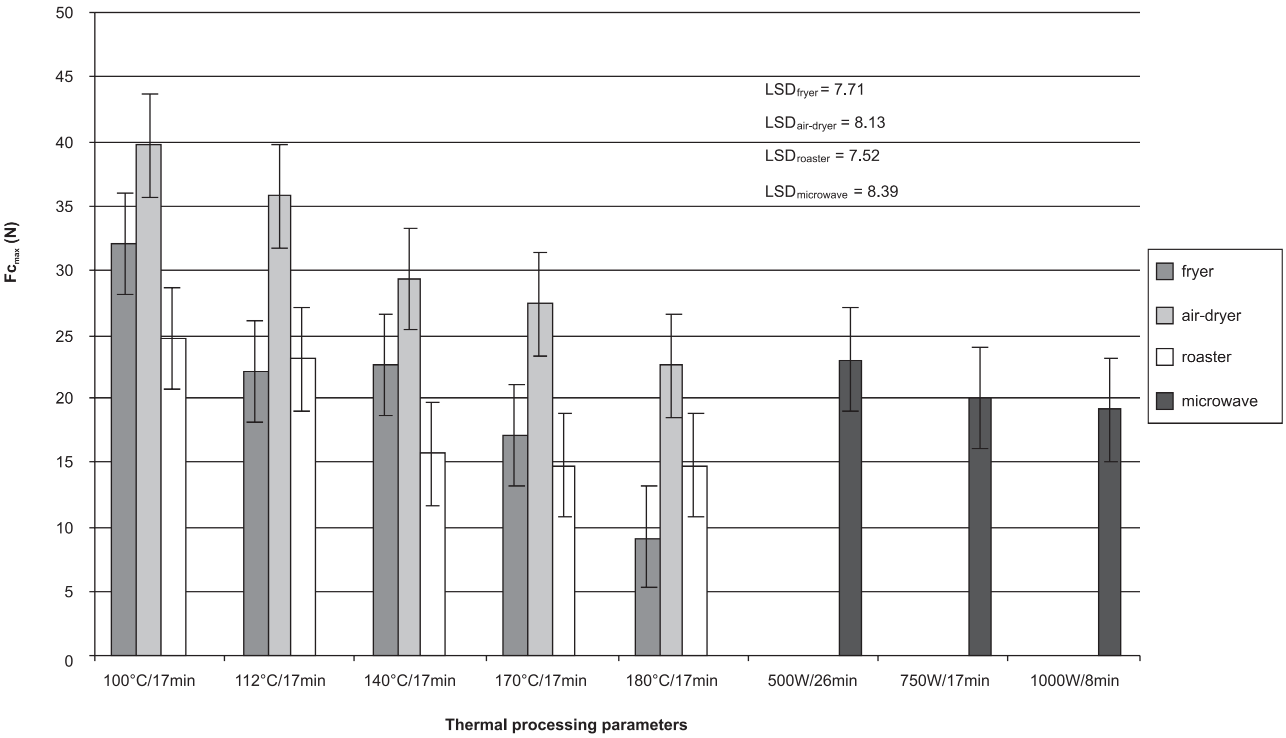

FIGURE 3. Texture of peanuts thermally-processed using different methods.

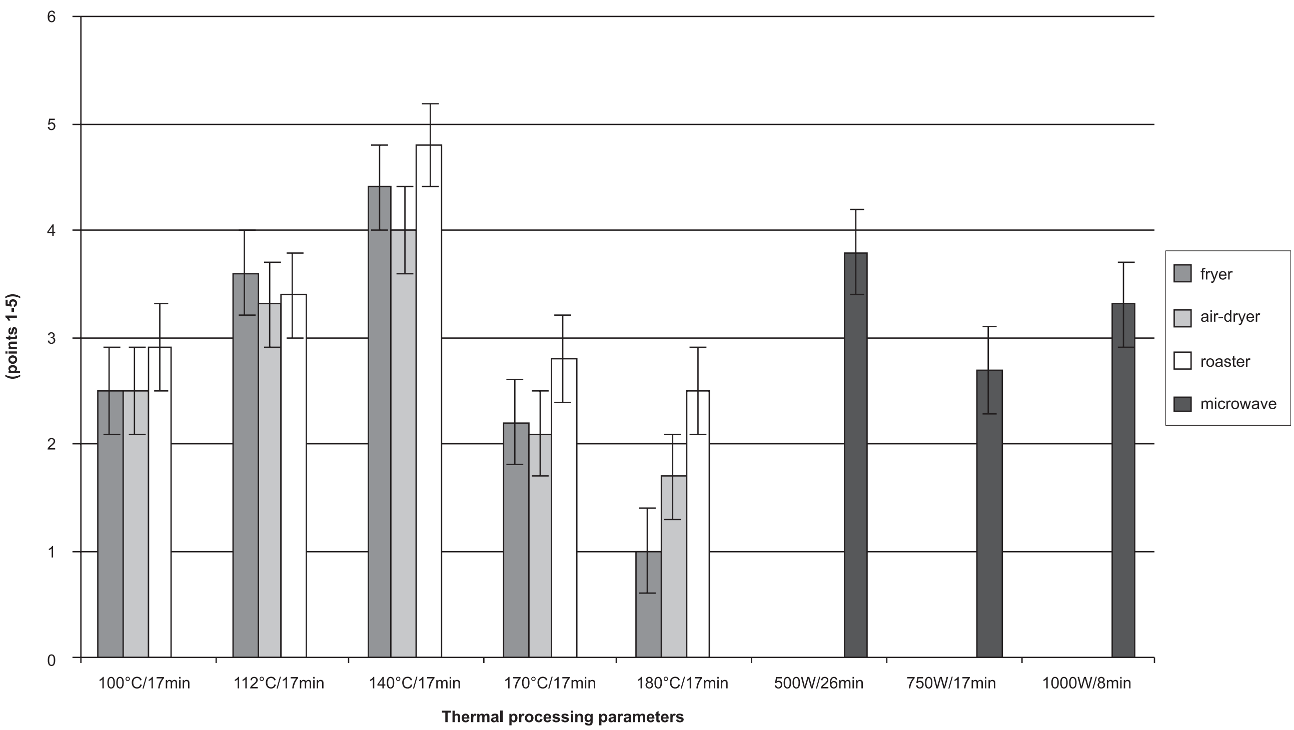

FIGURE 4. Overall oraganoleptic assessment of peanuts thermally-processed using different methods.

In the course of thermal processing peanuts colour also underwent alterations (Table 3). Regardless the method applied, thermal treatment resulted in darker peanut colour. The most considerable alterations featured the colour of peanuts deep-fried in the oil and roasted in the roaster, which exhibited too dark colour when roasted at the highest temperature. According to Bolton *et al.* [2002], lightness (L*) of appropriately roasted peanuts should amount 49 and among the samples subjected to analysis the most similar values featured peanuts roasted at temperature of 140°C. The least significant alterations were observed for peanuts treated in a microwave. Similar results were obtained by Özdemir & Devres [2000] comparing colour of hazelnuts roasted at different temperatures. Nuts roasted above 140°C exhibited excessive share of redness.

Thermal processing effected on peanuts texture as peanuts became more crispy and less hard. Alterations in peanuts hardness, determined in an instrumental way as maximum force needed to break peanut halves were shown in Figure 3. Hardness of peanuts deep-fried in oil and roasted in air decreased as processing temperature increased. Significantly harder texture featured peanuts roasted in a dryer in comparison to those roasted in a roaster. Hot air flow considerably accelerates water vaporation and, therefore, structural alterations in peanuts as well. This allows to obtain desired properties of a ready product within a shorter time and using lower temperatures. Peanuts processed in a microwave were characterised by similar hardness, regardless the parameters of processing. Misra [2004] analysed correlations between moisture of roasted peanuts and their hardness. He also stated that with decreasing moisture in roasted nuts, their hardness decreased.

Peanuts texture did significantly effected on the overal organoleptic assessment of nuts subjected to examination (Figure 4). The highest assessment values (more than 4 points) gained nuts processed at the temperature 140°C, while the lowest ones – when processing temperature ranged 180°C. Among those samples the lowest assessment values belonged to peanuts deep-fried in oil, which featured too dark colour, as well as bitter and burning flavour. Among peanuts processed in a microwave the highest assessment obtained nuts subjected to processing at the highest power applied (500W).

CONCLUSIONS

It has been stated that peanut properties depended on the method of thermal processing and parameters applied. As the temperature increased, air flow speed, power (regardless the method) and moisture show decreased values. Nuts deep-fried in oil were characterised by higher fat content as compared to the ones roasted in hot air or treated in microwave. The method and parameters of thermal processing effected on the properties of peanut fat fraction – acid value remained unchanged, while peroxide value underwent alterations according to the temperature. Peanut colour, alike, proved to be effected by thermal processing – the higher temperature the darker peanut colour. The most considerable alterations were recorded for peanuts deep-fried in oil and roasted with the use of dry method, *i.e.* hot air follow of the temperature ranging 170°C and 180°C. The method of roasting also influence peanut texture – the most delicate nuts were obtained when deep-frying in oil and roasting in a roaster with air flow, while the hardest ones resulted from dry method without air flow. The most advantageous organoleptic properties, regardless the methods, featured the peanuts thermal processed at the temperature of 140°C.

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WPŁYW RÓZNYCH PARAMETRÓW OBRÓBKI TERMICZNEJ NA WŁAŚCIWOŚCI ORZECHÓW ARACHIDOWYCH

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Celem pracy było porównanie właściwości fizykochemicznych i organoleptycznych orzechów arachidowych prażonych w gorącym powietrzu – z przepływem i bez, smażonych w oleju oraz ogrzewanych mikrofalowo.

Stwierdzono, że właściwości orzechów arachidowych zależały od metody i parametrów obróbki termicznej. Wraz ze wzrostem temperatury, prędkości przepływu powietrza oraz mocy, (niezależnie od metody), wilgotność orzechów ulegała obniżeniu. Orzechy smażone w oleju charakteryzowały się wyższą zawartością tłuszczu w porównaniu z orzechami prażonymi w gorącym powietrzu bądź mikrofalowo. Rodzaj i parametry obróbki termicznej wpłynęły na właściwości frakcji tłuszczowej orzechów – zmianom nie uległa liczba kwasowa, natomiast liczba nadtlenkowa zmieniała się w zależności od temperatury. Prażenie wpłynęło na barwę orzechów –im wyższa temperatura tym ciemniejsza była barwa orzechów. Największe zmiany barwy nastąpiły w orzechach smażonych w oleju oraz prażonych na sucho w przepływem gorącego powietrza w temperaturach 170 i 180°C. Metoda obróbki termicznej wpłynęła na konsystencję orzechów – najdelikatniejsze orzechy uzyskano podczas smażenia w oleju oraz prażenia w prażalniku z przepływem powietrza, a najtwardsze przy prażeniu na sucho bez przepływu powietrza. Najlepszymi właściwościami sensorycznymi, niezależnie od metody, charakteryzowały się orzechy poddawane obróbce termicznej w temperaturze 140°C.