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EFFECT OF THERMAL TREATMENT PARAMETERS ON SELECTED PROPERTIES OF POTATO CHIPS

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A b s t r a c t. The aim of the conducted investigation was to determine of the effect of different frying temperatures and drying methods (in hot air flow and microwave-convective at 240W, 360W and 480W) on fat content, texture, colour and sensory properties of potato chips. The material for our investigation were potato chips fried in palm oil at the temperature of 155°C and 175°C to 3% of moisture and then post-dried using different methods to a moisture level below 2%. Control sample were potato chips fried to less than 2% moisture. The following parameters were the subject of determination: moisture, fat content, texture – using the Instron 5544 apparatus, colour – by Minolta CR-200 colorimeter, and sensory properties (colour, flavour, taste and texture – according to 1-5 point scale). The investigations proved that application of lower frying temperature and shorter frying time followed by post-drying produced chips with considerably decreased fat content, increased hardness, as well as lighter colour. The worst sensory properties were obtained in chips post-dried in hot air, while the best – in those microwaved at the higher power level.

K e y w o r d s: Potato chips, drying, microwave, fat content, texture, colour, sensory assessment

INTRODUCTION

Potato chips, one of the most popular snack products obtained from potatoes, owe their popularity to unique sensory properties. They are produced from thin potato slices subjected to frying at high temperature and should feature gold-yellow colour, specific potato-oily taste and flavour, as well as crispy and delicate texture. Another characteristic feature is relatively high fat content (33-39%) (Lisińska and Leszczyński 1989).

High fat content and the presence of acrylamide - a substance of potential carcinogenic effect in humans, which originates from chips frying process, have recently led to undertaking intensive research on the improvement of health value of chips (Mellema 2003; Friedman & Levin 2008). Special attention has been paid to problems connected with acrylamide formation and on elaborating methods enabling either elimination or at least a reduction in the amount of this harmful compound in ready products. A number of solutions have been proposed regarding the application of many blanching solutions, introduction of pre-drying of potato slices before frying, or the use of vacuum fryers (Friedman and Levin 2008). Although those proposals were effective as far as acrylamide content reduction is concerned, they often resulted in worsening of other properties and they were too expensive or time consuming to be used in practice. Therefore, the first modification introduced on the industrial scale was lowering of the temperature of frying – initially to 175°C. Another option can be shorter time of frying and then drying (post-drying) of chips to appropriate moisture (below 2%), which additionally reduces fat content in ready product (Kita *et al.* 2004). The methods of post-drying, already analysed in previous examinations, either took too long time (convection drying), or caused significant deterioration of the properties of the resulting chips (vacuum drying and microwave–vacuum drying) (Kita & Figiel 2008). An alternative method of post-drying can be the application of microwaves in convection (Porter *et al*. 1973).

The aim of this work was assessment of the effect of frying temperature and different methods of post-drying (in hot air flow and microwave-convection) on fat content, texture, colour and sensory properties of potato chips.

MATERIALS AND METHODS

Potatoes of cv. Karlena were used for laboratory potato chips production. After washing and peeling (carborundum peeler, Sirman, Italy), the potatoes were cut into slices of 1.6±0.1 mm in thickness (slicing machine, Ma-Ga 250.6, Poland), washed in cold water, superficially dried (paper towels) and fried in a fryer (Beckers, Italy) until the moisture content was 3% and below 2%. The potato chips were fried in palm oil heated to 155°C and 175°C. After removing from the oil and cooling, potato chips with moisture content higher than 2% were post-dried using convective dryer and microwave-convective dryer at three power levels of 240 W, 360 W and 480 W (Plazmatronika, Poland). Next, 100 g samples of potato chips were packed in aluminium foil packages and taken for laboratory analysis. All experiments were performed in triplicates and the results shown in the present paper are the mean values obtained in the investigation.

Moisture content in potato chips was determined by drying 2g homogenized samples in a hot air oven at 105^{o}C for 2h (AOAC). Fat content of potato chips was estimated using the Soxhlet procedure (AOAC). Fat was extracted applying a Büchi B-811 Universal extraction system (Büchi Labortechnic AG, Flawil, Switzerland). A 2g sample was extracted for 180 min with diethyl ether used as a solvent.

The texture of potato chips was determined using an Instron 5544 connected to a computer and equipped with a “share blade”, a rectangular attachment for cutting (70 mm x 3 mm). The velocity of the head with the attachment was 250 mm/min with a 2 kN load cell. The measurements were taken for determining maximum shear force (Ft_{max}) necessary to cut one slice of potato chips. Each measurement was conducted on 30 potato chips (Kita *et al.* 2007).

The colour of potato chips was assessed with the use of a Minolta Chroma Meter CR-200 Reflectance system. The device is a tristimulus colorimeter which measures four specific wavelengths in the visible range, as specified by the Comission Internationale de l’Esclairage (CIE). Tristimulus data supply a three-dimensional value to equal perceived colour differences. The *L**, *a**, and *b** values are three dimensions of a measured colour which give a specific colour value of the material. The *L** value represents light-dark spectrum with a range from 0 (black) to 100 (white). The *a** value represents green-red spectrum with the range from -60 (green) to +60 (red). The *b** value represents blue-yellow spectrum with the range from -60 (blue) to +60 (yellow). The measurements were conducted after milling potato chips to uniform grind size on 10 g chips samples from all frying and post-drying conditions (Papadakis *et al.*, 2000).

The sensory qualities – colour, flavour, odour and texture - were assessed according to the five-grade scale (5 points – the best, 1 point – the worst).

One-way analysis of variance was used for comparison of the results obtained with fat content and texture of potato chips. Homogenous groups were determined using the Duncan test ($p \leq 0.05$). The data were analysed using the Statistica 6.0 software.

RESULTS AND DISCUSSION

Figure 1 presents the fat content in potato chips fried at two temperatures and post-dried according to the convection or microwave-convection method. Lowering of frying temperature from 175^{o}C to 155^{o}C resulted in higher fat content in chips (on average by 3%). Similar relations were obtained in other experiments where chips were fried in different oils and at different temperatures (Kita *et al.* 2007). Shortening of frying time followed by post-drying lowered the fat content in the final product by another 3% on average. The parameters of post-drying did not affect the fat content in chips. In previous experiments involving the application of the vacuum method and the vacuum-microwave method to post-drying, fat loses were observed as side effects (Kita and Figiel 2008).

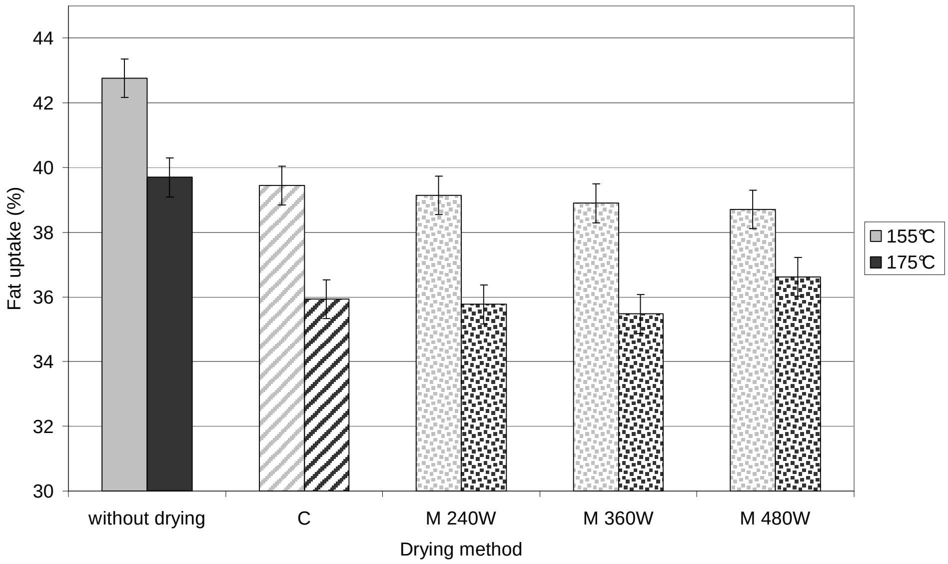

Fig. 1. Fat uptake of potato chips fried at different temperatures and next post-dried using convective (C) or microwave-convective (M) methods

The temperature of frying, as well as the parameters of post-drying, did influence the resulting chips texture (Fig. 2.). Chips previously fried at lower temperature and subjected to post-drying exhibited harder texture in comparison to those fried at 175°C. Similar results were reported by other authors who compared the effect of frying temperature on potato chips texture (Gamble *et al.* 1987; Kita *et al.* 2007). Application of post-drying influenced chips hardness. The hardest texture was exhibited by chips after convection method of post-drying or the microwave one at power of 240 W. Yet, as the power of microwave post-drying increased, hardness of chips decreased. The most delicate texture, similar to that of chips obtained without post-drying, was featured by chips post-dried in microwaves at the power of 480W. In another experiment involving comparison of the effects of other drying methods on chips texture, the latter one was harder as compared to chips obtained without post-drying, regardless of the method applied (Kita and Figiel 2008).

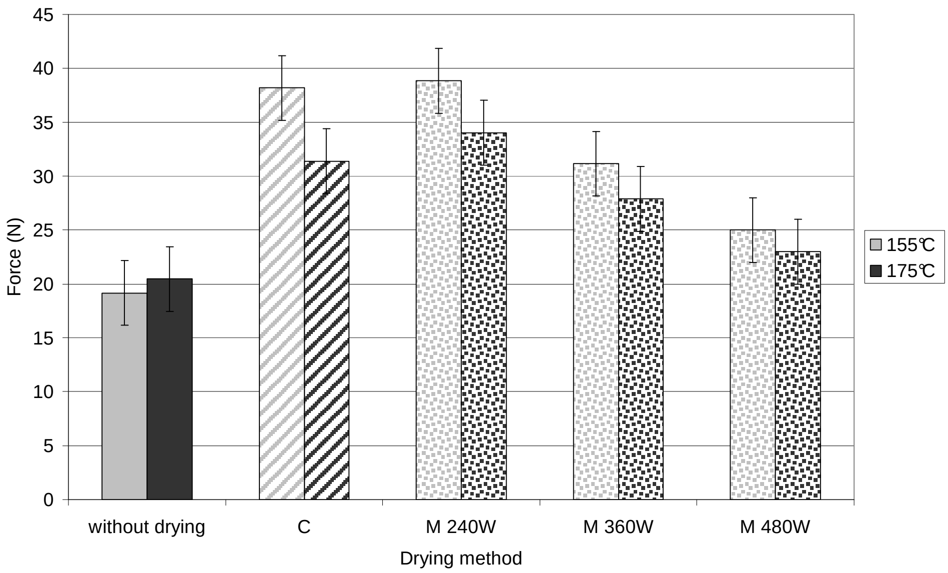

Fig. 2. Texture of potato chips fried at different temperatures and next post-dried using convective (C) or microwave-convective (M) methods

Introduction of shorter frying time followed by post-drying influenced the colour of resulting chips (Fig. 3-5). Chips were getting lighter (L^*) as the power of microwaves used for post-drying increased. While the temperature of frying did not affect chips colour when traditional or convection method of obtaining chips was applied, in the case of the microwave-convection method of post-drying the chips previously fried at lower temperature featured significantly lighter colour. Similar relations were reported when the remaining parameters of colour were concerned. Introduction of post-drying resulted in a decrease in the value of parameter a^* and the least significant changes were observed in chips post-dried by the convection method (at 175^{o}C), while the most pronounced changes were recorded for the microwave method of post-drying, at the highest power (480 W). The values of parameter b^* increased as microwave power increased (Fig. 5).

The influence of thermal parameters on chips colour was also observed by other authors. Pedreschi *et al.* (2007), frying chips at different temperatures (120-180^{o}C), observed that the colour of chips was getting lighter as the temperature of frying decreased. Additional lighter shade of chips colour was observed when pre-drying of potato slices was introduced before frying. Tronsoco *et al.* (2009) confirmed these observation results while potato chips were fried using the traditional and vacuum methods.

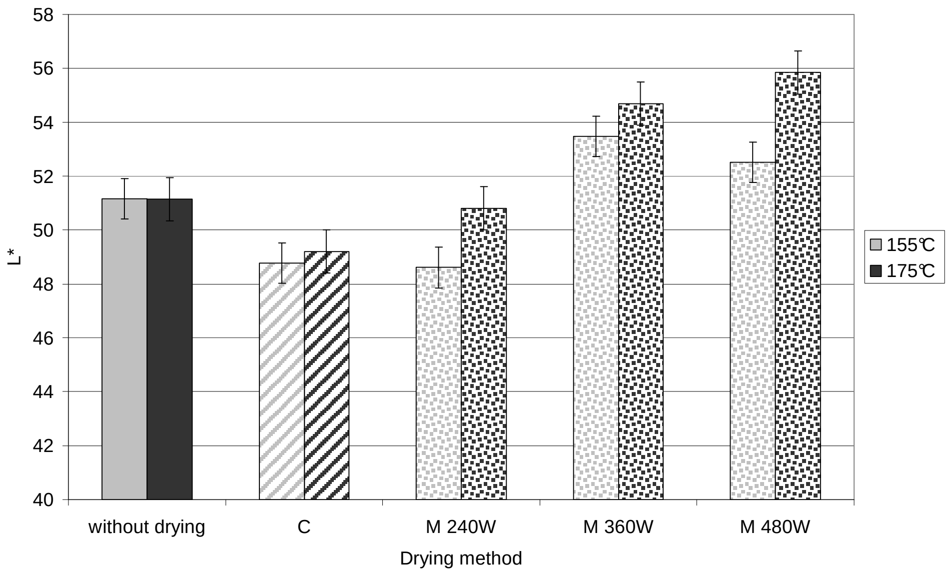

Fig. 3. Colour (L*) of potato chips fried at different temperatures and next post-dried using convective (C) or microwave-convective (M) methods

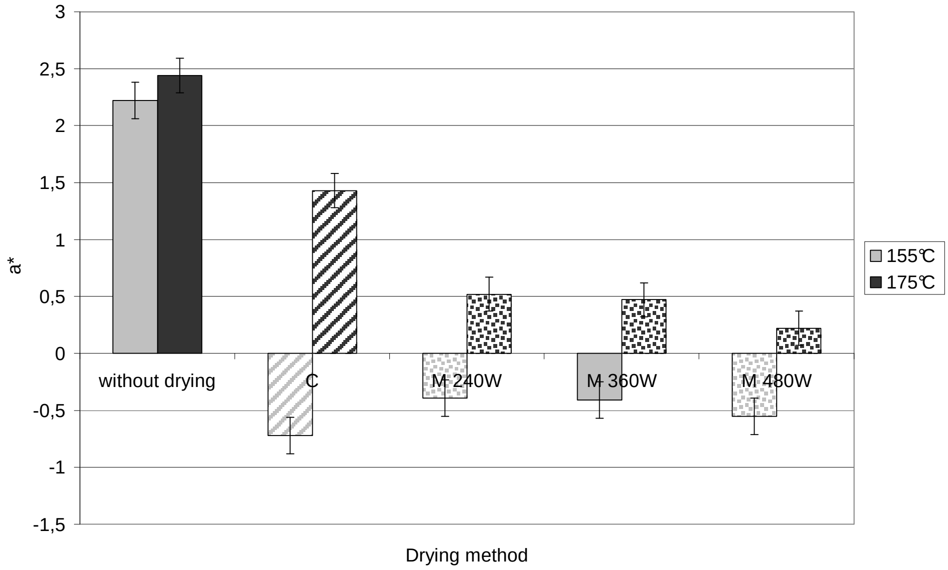

Fig. 4. Colour (a*) of potato chips fried at different temperatures and next post-dried using convective (C) or microwave-convective (M) methods

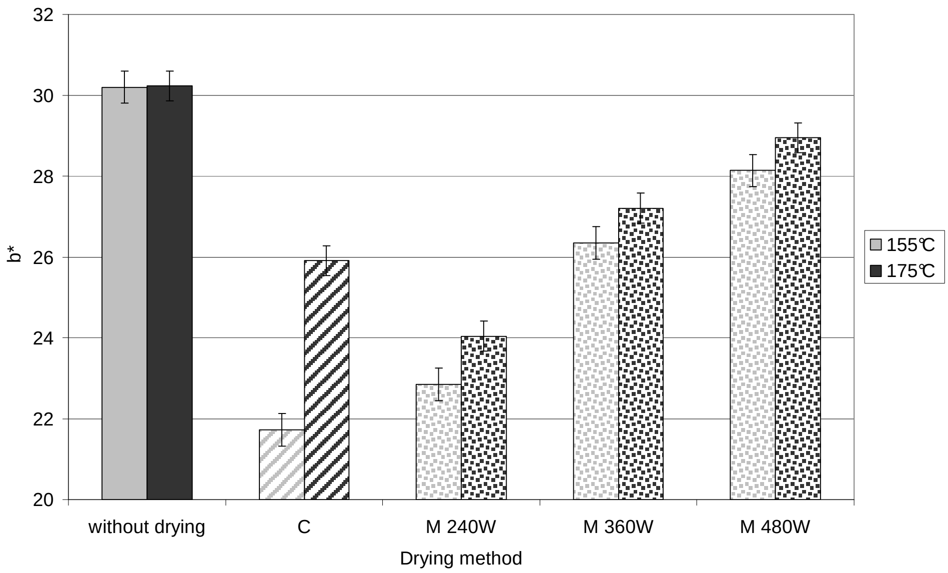

Fig. 5. Colour (b*) of potato chips fried at different temperatures and next post-dried using convective (C) or microwave-convective (M) methods

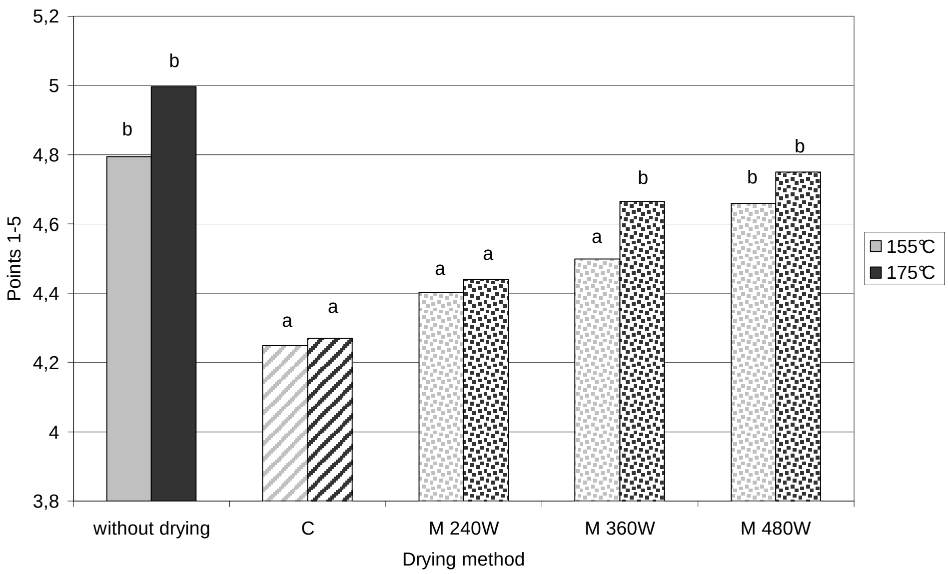

Fig. 6. Total sensory assessment of potato chips fried at different temperatures and next post-dried using convective (C) or microwave-convective (M) methods

The results of total sensory assessment of chips are shown in Figure 6. The temperature of frying had no significant effect on chips quality parameters, although slightly higher notes were obtained by chips fried at higher temperature. Application of post-drying worsened the quality of chips obtained. The lowest notes were obtained by chips post-dried in hot air or using the microwave-convection method at the lowest microwave power (240 W). The quality of chips increased as microwave power increased. In another experiment, when chips were post-dried by the vacuum or microwave-vacuum method, application of post-drying did result in worsening of the quality of chips (Kita & Figiel 2008). Similarly, application of pre-drying prior to frying did worsen the quality of chips (Tronsoco *et al.* 2009).

CONCLUSIONS

1. Application of lower frying temperature and shorter frying time followed by post-drying considerably decreased fat content in finally produced chips.
2. Chips obtained using the post-drying process were characterised by harder texture as compared to those fried in the traditional way.
3. The hardness decreased with increase in the power level in microwave-convective post-drying.
4. Post-drying affected chips colour which was lighter than that of chips fried in the traditional process.
5. Among chips obtained using post-drying, chips post-dried in hot air featured the worst sensory properties, while the best were observed in chips microwaved at the higher power level.

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WPŁYW PARAMETRÓW OBRÓBKI TERMICZNEJ NA WYBRANE WŁAŚCIWOŚCI CZIPSÓW ZIEMNIACZANYCH

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Streszczenie. Celem przeprowadzonych badań było określenie wpływu temperatury smażenia i różnych metod dosuszania (w przepływie ciepłego powietrza i mikrofalowo-konwekcyjnie) na zawartość tłuszczu, konsystencję, barwę i cechy organoleptyczne czipsów ziemniaczanych. Materiałem użytym do badań były czipsy ziemniaczane smażone w oleju palmowym o temperaturze 155°C i 175°C do wilgotności 3%, a następnie dosuszane różnymi metodami do wilgotności poniżej 2%. Próbę kontrolną stanowiły czipsy ziemniaczane usmażone do wilgotności poniżej 2%. W czipsach oznaczano: wilgotność, zawartość tłuszczu, konsystencję – przy użyciu aparatu typu Instron 5544, barwę – przy użyciu kolorymetru Minolta CR-200 oraz cechy organoleptyczne: barwę, smak, zapach i konsystencję – według skali punktowej (1-5 pkt.) Stwierdzono, że zastosowanie niższej temperatury i skrócenie czasu smażenia a następnie dosuszanie czipsów obniża zawartość tłuszczu w produkcie, jego twardość i rozjaśnia barwę. Mikrofalowe dosuszanie przy wyższej mocy pozwala uzyskać czipsy o dobrych parametrach organoleptycznych.

Słowa kluczowe: czipsy ziemniaczane, dosuszanie, zawartość tłuszczu, tekstura, barwa, ocena sensoryczna