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EFFECT OF POST-DRYING METHOD ON SELECTED PROPERTIES OF POTATO CHIPS

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A b s t r a c t. The aim of the investigation conducted was determination of the effect of different drying methods (in hot air flow, vacuum and vacuum-microwave dryers) 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 175°C to range 20%, 15% and 5% of moisture and then post-dried using different methods to 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 Instron 5544 device, colour – by Minolta CR-200 colorimeter, and sensory properties (like colour, flavour, taste and texture – according to 1-5 point scale). Investigations proved that shortening frying time and then post-drying decreases fat content in chips product and increases chips hardness, as well as results in chips lighter colour. It was suggested that post-drying applied at lowered pressure requires assorting appropriate parameters of the process.

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

INTRODUCTION

Potato chips are known as one of the most popular kinds of fried snacks made from potatoes. For 150 years they have enjoyed high popularity both in the USA and in the European countries, which they owe to their specific sensory properties – characteristic colour, taste and flavour (due to the combination of features of raw materials used: potato, oil and spices), but, first of all, to their crispy texture. Obtained through frying thin potato slices in hot oil, chips are characterised by relatively high content of fat (30-35%) and low amount of water (<2%) (Lisińska and Leszczyński, 1989).

In recent years more and more attention has been paid to health aspects of food. Therefore, there have been undertaken trials to modify technology in view of lowering the fat content without worsening the quality of the final product. To this end there are used different kinds of blanching solutions, slice drying prior to their frying, as well as combinations of appropriate frying parameters (time and temperature) (Mellema 2003). It is also possible to manipulate the kind of frying oil, although nowadays, on an industrial scale, palm oil and its fractions is a dominant one and it successfully eliminates other, often less hydrogenised vegetable oils (Kita *et al.* 2007).

The presence of acrylamide has turned out to be not of the least importance. This is a substance featuring potentially cancerogenous effects for people and it can be found in carbohydrate products undergoing thermal processing. Especially high quantity of this undesired compound, many times exceeding the norms in force, have been detected in potato chips, therefore, in the last years numerous investigations were undertaken, aiming at limiting or complete elimination of acrylamide from this popular product (Claeys *et al.* 2005). One of the first modifications introduced in technology was lowering of chips frying temperature (from 185°C to 175°C or lower) (Gertz and Klosterman, 2002). Another proposal involved, among others, shorter frying period and then post-drying chips until they reach moisture levels below 2% (Kita *et al.* 2004).

Such modifications not only result in decreased content of acrylamide, but also affect other quality properties. In connection with the mentioned fact the aim of this investigation was determination of the degree of chips frying at the temperature of 175°C to different moisture levels and then post-drying effects on the properties of the final product. Also, a comparison was made of different methods of post-drying – in a convectional dryer, vacuum, or in a vacuum-microwave dryer in view of the resulting quality of potato chips.

MATERIALS AND METHODS

Potato variety Eldena was used for laboratory potato chips production. After washing and trimming (carborundum peeler, Sirman, Italy), the potatoes were cut into slices of 1.8±0.1 mm in thickness (slicing machine, Brown, Germany), washed in cold water, superficially dried (paper towels) and fried in a fryer (Beckers, Italy) until the moisture content was 20%, 15%, 5% and below 2%. The potato chips were fried in palm oil heated to 175^{o}C. After discharging of the oil and cooling, potato chips with moisture content higher than 2% were post-dried using convectional dryer, vacuum dryer (SPT-200, Poland) and vacuum-microwave dryer (Plazmatronika, Poland) – Table 1. 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.

Table 1. Parameters of post-drying of potato chips fried at different moisture levels

Moisture content of potato chips after frying (%)	Type of post-drying		
	convection (50 °C)	vacuum (50°C/1kPa)	vacuum-microwave (480W/4-6kPa)
5	2 h	1 h 15 min	2-3 min
15	2 h 30 min	1 h 30 min	3.5-6 min
20	2 h 45 min	1 h 30 min	4.5-8.5 min

Moisture content in potato chips was determined by drying 2 g homogenized samples in hot air oven at 105°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, equipped with a "share blade" rectangular attachment for cutting (70 mm x 3 mm). The velocity of the head with the attachment was 250 mm min^{-1} with a 100 kG load cell. The measurements were taken to determine the maximum shear force (Ft_{max}) necessary to cut one slice of potato crisp. 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 visible range, 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 gives 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 crisps to unified grind size on 10 g crisps 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 for the fat content and texture of potato chips. Homogenous groups were determined using the Duncan test ($p \leq 0.05$). The data were analysed using Statistica 6.0 program.

RESULTS AND DISCUSSION

Figure 1 shows moisture and fat content alterations in potato chips fried in palm oil heated to 175°C. The longer the frying time the lower the water content in chips recorded, and the alterations mentioned were described using a sigmoidal curve. The highest water loss took place between 2 and 3 minutes of frying. After that time chip moisture values reached a similar level (<2%). Water loss, depending on frying temperature as well as on other parameters, in the course of chips frying was the subject of investigation by other authors (Gamble *et al.* 1987, Moyano *et al.* 2006). They observed increasing pace of water evaporation as the temperature was going up.

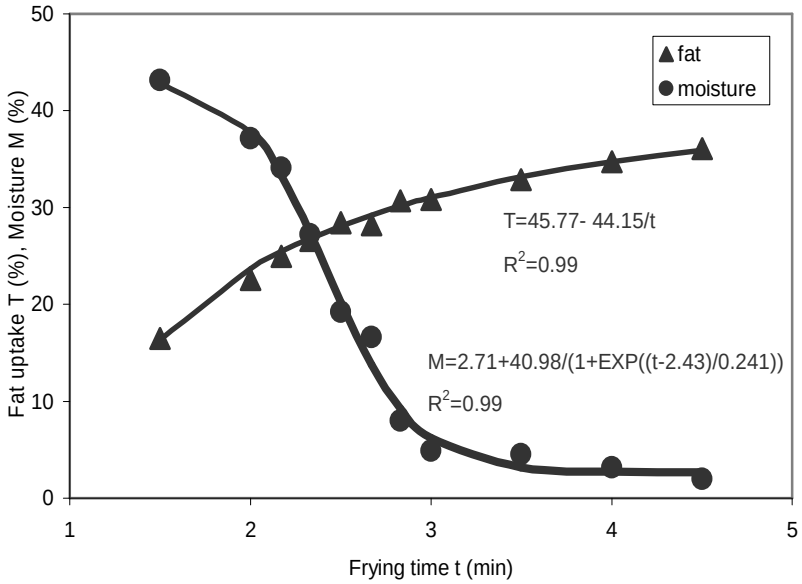

Fig. 1. Moisture and fat content of potato chips fried in palm oil at 175°C

In the process of frying the space once occupied by evaporated water becomes filled with frying fat. The pace of fat absorption in the experiment conducted was described by a hyperbolic curve. As frying time prolonged fat content in chips increased and after 4.5 minutes it ranged at 35%. Similar relations were

recorded by other authors who compared the amount of fat absorbed, both during classical frying and in a vacuum process (Gamble and Rice 1987, Garayro and Moreira 2002, Pedreschi and Moyano 2005b).

The relation between chips moisture and their fat content when fried at temperature 175° C is shown in Figure 2. Slight changes of the moisture were observed when fat content did not exceed 25%, and when it exceeded 30%. The increase in fat content within the range from 25 to 30% was accompanied by the decrease in chips moisture from 35 to 10%.

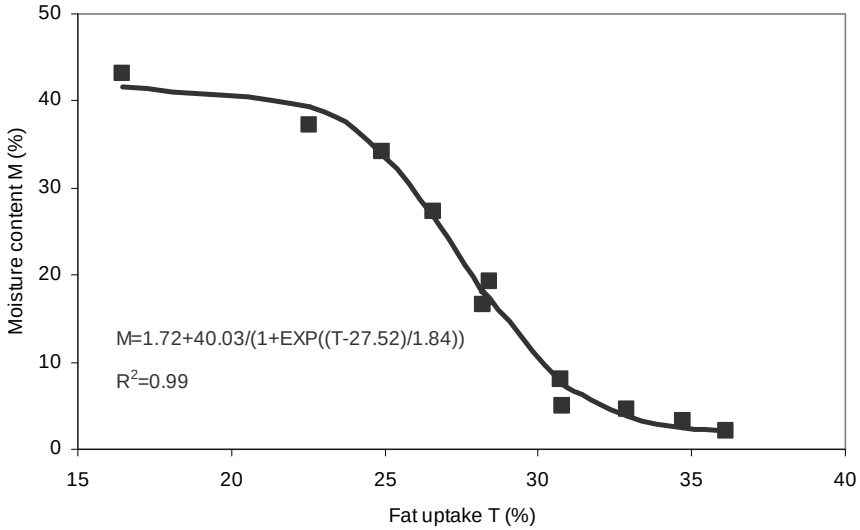

Fig. 2. Relationship between moisture and fat content of potato chips fried in palm oil at 175°C

Potato chips obtained featured different fat content (Fig. 3). The longer the frying time of potato slices in oil the higher the fat content charactering ready products. Therefore, introduction of shorter frying and then post-frying chips to appropriate moisture level significantly lowered the content of the component in ready products. However, different fat contents were recorded between the chips post-dried according to different methods. Post-drying performed both in a vacuum dryer and in a vacuum-microwave one caused fat loses as fat remained on the surface of glass containers where the drying took place. Probably the applied parameters resulted in too intensive fat vaporisation from the surface of the product. Therefore, considering the methods of drying a product previously subjected to frying, there is a need to determine the parameters which would not allow loses of that component. The effect of different technological treatments on fat content in potato chips was the subject to examination of many researchers. Gamble *et al.* (1987), comparing fat content in chips obtained

from pre-dried potato slices, noticed that both pre-drying in hot air and with the use of microwaves resulted in lower fat content in final product. Pedreschi and Moyano (2005a) also came to the same conclusions as the recorded lowered fat content in pre-dried blanched potato slices.

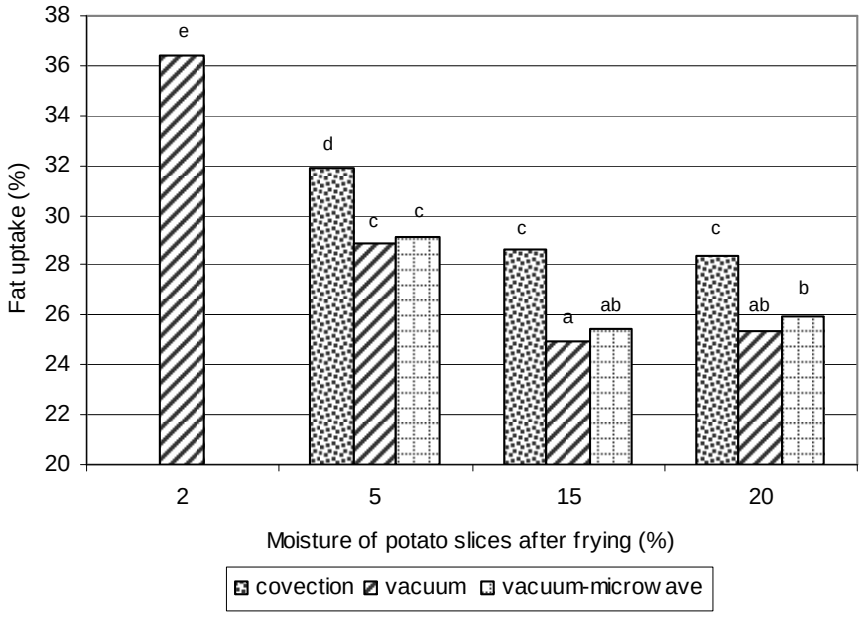

Fig. 3. Fat content of potato chips fried at different moisture levels and next post-dried

Fat content and moisture are directly related to chips texture. The results of texture measurements regarding chips hardness are shown in Figure 4. The most delicate texture was featured by chips fried in a traditional way – directly to their moisture level below 2%.

Introduction of shorter frying and then post-drying according to conventional method affected chips increased hardness: by 1 N – when slice moisture amounted to 5% and by 4 N – at slice moisture of 15 and 20%. Chips post-dried in vacuum and vacuum-microwave dryer were characterised by harder texture (1-1.5 N) in comparison to chips dried using the conventional method.

Another investigation involving the texture of chips featuring different fat content proved a similar relation – the lower the fat content the harder the chips (Kita *et al.* 2007). Pedreschi and Moyano (2005a), comparing the texture of chips

subjected to blanching and pre-drying, recorded the fact that those treatments did significantly increase crispiness of potato chips.

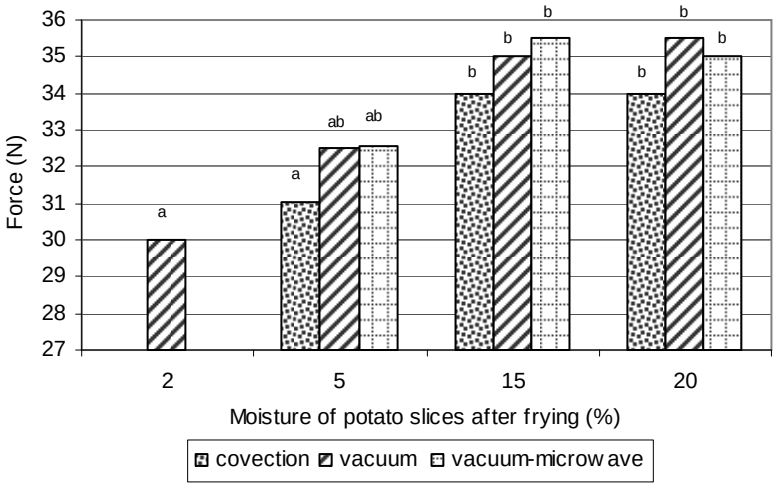

Fig. 4. Texture of potato chips fried at different moisture levels and next post-dried

An equally considerable chips quality parameter is their colour. The results of colour assessment of ready products based on Chroma Minolta CR-200 colorimeter indications are presented in Table 2. Applied post-drying resulted in lighter colour of the final product (higher values of L* parameter) and decreased values of a* and b* parameters. There were recorded different colour intensities of L* and in contribution of red colour a* in chips obtained from slices post-dried to 5% moisture and to higher moisture values. The method of post-drying did not signi-

Table 2. Colour (L,a,b) of potato chips fried in different oils and post-dried using air-dryer, vacuum-dryer and vacuum-microwave dryer

	Without	Type of post-drying								
		convection			vacuum			vacuum-microwave		
	2%	5%	15%	20%	5%	15%	20%	5%	15%	20%
L	53.35	59.22	63.46	59.75	57.3	61.26	61.44	60.34	63.64	60.28
a	1.63	0.24	–2.86	–2.16	–1.45	–2.63	–0.97	–0.45	–3.1	–2.32
b	30.02	26.09	26.04	24.18	25.14	27.85	25.36	25.17	27.75	23.26

ficantly affect this quality parameter. Alterations in chips colour according to frying parameters were also investigated by other authors. Gökmen and Şenyuva (2006) stated that regardless of the temperature applied, as frying time prolonged L* and b* parameters decreased, while a* reached higher values. Pedreschi *et al.* (2007), comparing the colour of chips obtained from pre-dried potato slices, noticed distinctly lighter colour of the resulting product.

The results of general sensory assessment of potato chips are shown in Figure 5. The chips to reach the highest assessment note were those traditionally fried, as well as the ones made of potato slices initially dried to 5% moisture level and then post-dried according to the conventional method. Comparing the properties of chips post-dried using different methods, chips conventionally post-dried proved to be the best (although the time consumed by this process was the longest), while the worst assessment was given to vacuum post-drying. Worse assessment of chips dried at lowered pressure was connected with the leakage of fat whose boiling point underwent considerable lowering in those conditions.

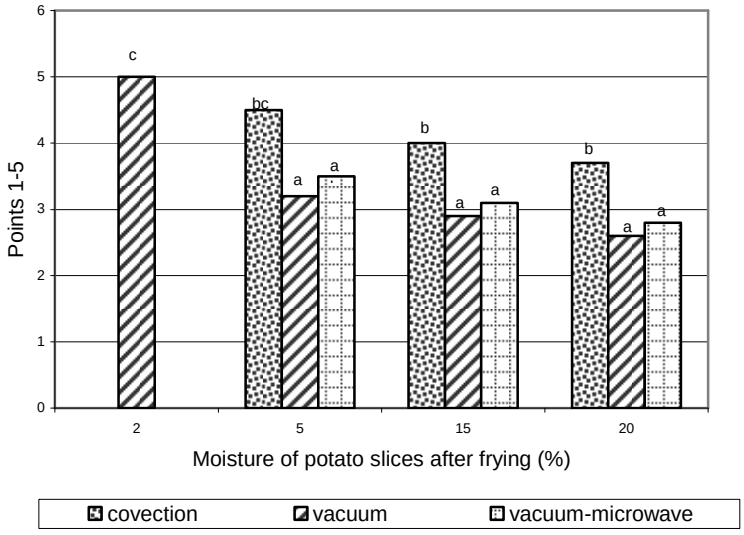

Fig. 5. Total sensory assessment of potato chips fried at different moisture levels and next post-dried

CONCLUSIONS

1. Application of shorter frying time followed by post-drying considerably decreased fat content in finally produced chips.

2. Potato slices post-dried with the use of vacuum and microwave dryers featured fat losses in ready product.

3. Chips obtained using post-drying process were characterized by harder texture as compared to the ones dried in the traditional way.

4. Post-drying affected chips colour which was lighter than that of classically dried ones.

5. Among chips obtained using post-drying, chips conventionally post-dried featured the best sensory properties. Application of other, quicker post-drying methods requires the selection of appropriate parameters of the process.

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WPŁYW RÓŻNYCH METOD DOSUSZANIA NA WYBRANE WŁAŚCIWOŚCI CZIPSÓW ZIEMNIACZANYCH

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S t r e s z c z e n i e. Celem przeprowadzonych badań było wyznaczenie wpływu różnych metod dosuszania (w przepływie ciepłego powietrza, próżniowo i mikrofalowo-próżniowo) na zawartość tłuszczu, konsystencję, barwę i cechy organoleptyczne czipsów ziemniaczanych. Materiałem użytym do badań były czipsy ziemniaczane smażone w oleju palmowym o temperaturze 175^{o}C do wilgotności 20%, 15%, i 5%, 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 skrócenie czasu smażenia a następnie dosuszanie czipsów obniża zawartość tłuszczu w produkcie, zwiększa jego twardość i rozjaśnia barwę. Zasugerowano, że stosowanie dosuszania przy obniżonym ciśnieniu wymaga dobrania odpowiednich parametrów procesu.

S ł o w a k l u c z o w e: czipsy ziemniaczane, dosuszanie, zawartość tłuszczu, tekstura, barwa, ocena sensoryczna