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EFFECT OF PRE-DRYING METHOD ON THE QUALITY AND MECHANICAL PROPERTIES OF FRENCH FRIES

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Application of microwave drying method in the process of pre-drying potato strips before frying can determine French fries quality to much higher degree, than convective methods. The aim of the work was determination of the effect of the method and degree of pre-drying potato strips after blanching on fat content in French fries and their mechanical and organoleptic properties.

It was stated that the pre-drying applied to French fries resulted in decreased fat absorption, during I stage of frying, regardless drying method used and more satisfactory results were obtained at dehydration by 1-3%. French fries pre-dried by microwave methods characterized better organoleptic properties than the ones pre-dried by convective method. French fries became harder as the degree of pre-drying of potato strips increased and pre-drying according to convective method proved to be the least advantageous for French fries texture. Microwave drying at magnetrons power level 480W occurred to be the most appropriate method of French fries pre-drying before frying.

INTRODUCTION

Consumers demands regarding French fries quality are quite high and they seem to continuously grow. First of all, there are assessed such basic quality determinants as: colour, taste and odour, then consumer's attention is focused on fat content in fried product and its texture [Lisińska & Leszczyński, 1989; Lisińska, 2006].

Colour is an important factor deciding about the acceptance of fried product by consumers. French fries, regardless the way they are produced, should be of light, golden colour, without brown penetrations, black spots or streaks and they should feature even length and regular shape [Talburt & Smith, 1987; Agblor & Scalon, 2000].

French fries odour and taste beside the colour are quality determinant which was first obtained. French fries odour and taste, apart from colour, should be specific, potato-oily, without any flavour of bitterness, burning or rancid fat [Talburt & Smith, 1987; Lisińska & Leszczyński, 1989].

Another considerable quality determinant of French fries and their acceptance on the part of consumers is fat content. French fries with too high fat content are of oily taste, while too low fat content deprive French fries of taste and smell typical for fried products. Fat content in French fries depends on both raw material parameters i.e. chemical composition of potato tubers, and technological factors like: strip thickness, kind and parameters of blanching, pre-drying and frying [Lisińska & Leszczyński, 1989]. The amount of fat absorbed by a product in the course of frying depends not only on the temperature and time of the process, but also on the kind of oil used [Kita *et al*., 2007; Mellema, 2003; Saguy & Dana, 2003].

One of more significant sensory properties of fried potato products is their crispy, delicate texture [Tajner-Czopek 2003]. Texture of French fries has two meanings: external texture – crispness, and internal texture-mealiness. The external layer of French fries should be crisp and tender, without hard, leathery or gummy texture, whereas the interior should be mealy, not watery or mushy, and there should be no separation between crust. When broken, French fries surface should be smooth, without any cracks [Talburt & Smith, 1987; Lisińska & Leszczyński, 1989].

Texture is determined by a structure, shape, chemical composition, viscosity and other physical properties of a product [Lisińska & Leszczyński, 1989; Szczesniak-Surmacka, 2002; Tajner-Czopek, 2003]. Consumers especially value the following texture properties: crispness, tenderness, delicateness, juiciness and sappiness, while they do not accept, *e.g.*: leathery, soaked, watery, disintegrating, nobly or mucous French fries [Bourne, 2002; Szczesniak-Surmacka, 2002]. In order to assess food texture, including fried potato products, *e.g.*: French fries, nowadays, there are different measuring techniques, which involve among the others, sensory methods (*e.g.* quantitative descriptive analysis – QDA) and instrumental methods using measuring devices of Stevens or Instron type). The latter ones enable conducting different tests (*e.g.*: shearing, bending or TPA tests) [Bourne, 2002]. Measurement of French fries by an objective method enables the determina-

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tion of selected properties: maximum shearing force (F_{max}), shear work (W) and shear stress (τ_{max}). The maximum values of shearing force, shear stress and shear work are mechanical properties which are important in assessing raw material damaged when harvested or transported [Gieroba & Dreszer, 1993] and the texture of the ready product for evaluation.

TPA test (Texture Profile Analysis) makes it possible to analyse French fries texture and, at the same time, to apply sensory and objective analysis [Szczesniak-Surmacka, 2002]. The basic properties which characterized of TPA test are cohesiveness, adhesiveness and hardness (texture) [Bourne, 2002].

French fries texture can be modified thought appropriate combination of technological parameters of particular selected stage of the process. The basic technological process includes: blanching, pre-drying, pre-frying and frying [Lisińska & Leszczyński, 1989; Abglor & Scalon, 2000]. Blanching is a one of the technological stages of French fries production, the proper choice of parameters for that stage enables obtaining good quality products as well as improvement of those properties of French fries which do not meet the norm [Lisińska & Leszczyński, 1989]. The results of properly combined parameters of blanching is unified, even of colour of French fries, decreased absorption of fat when fried and appropriate texture featuring ready product.

Another process which apart from blanching, can effect the improvement of French fries sensory properties is pre-drying of potato strips previously subjected to blanching. Pre-drying before frying has the following advantages: it is very easy to main uniform colour of the product during and after frying, product stability is optima, weak and soggy product is not obtained after the frying process, the oven-ready product stays crispy from the kitchen the table and the pre-dried product absorbs much less fat during frying [Lisińska & Leszczyński, 1989; Abglor & Scalon, 2000].

The process of pre-drying and drying, applied in food processing factory, can be conducted with the use of convective, microwave – at different magnetron power methods or the one which combines the mentioned methods. Microwave drying enables heating the material as a whole bulk, which considerably favors this technique in comparison to the conventional ones [Jones, 1992]. Additional advantage of microwave method is shortening of drying time, which means shorter time of exposing this material to oxygen contact at higher temperature and reduction of negative effects of biochemical alterations (*i.e.*: fat oxidation), as well as maintaining appropriate colour and nutritive value of product [Drouzas and Schubert, 1996].

Probably, application of microwave drying method in the process of pre-drying potato strips before frying can determine French fries quality to much higher degree than convective methods. Decreased fat content in French fries, maintaining their proper colour and texture of a ready product can speak for application of microwave method to pre-dry potato strips in spite of its high exploitation costs [Wang *et al*., 2004].

The aim of the work was determination of the effect of the method and degree of pre-drying potato strips after blanching on fat content in French fries and their mechanical and organoleptic properties.

MATERIALS AND METHODS

Materials. The material used for investigation were potatoes of Felsina cultivar, originating from French fries producing plant in the region of lower Silesia.

Analysis. Washed and peeled potatoes were cut into potato strips 10 x 10mm and then blanched in water at the temperature of 75° C for 10 min. Blanched potato strips were divided into five parts: first included blanched potato strips without pre-drying application (control sample), four residue of them were subjected to pre-drying, according to two methods: microwave and forced convective. Microwave pre-drying was followed at lowered pressure, and three magnetron power levels (240W, 480W and 720W) and changing pressure within the range from 4 kPa to 6 kPa, by the use of Plazmatronika SM 200 dryer. Another method involved forced convective at the temperature of 55°C at drying air speed amounting 4 m/s. Convective pre-drying method was done using drying equipment design and built up in the Institute of Agricultural Engineering (Wrocław University of Environmental and Life Sciences). The convective pre-drying enabled simultaneous drying of 6 batches of material. Pre-drying of potato samples according to each particular method was conducted within the range from 23% to 30% of dry matter, *i.e.*: decreasing potato strips moisture by 1, 3, 5 and 7%.

Then there were made fries using two-stage frying method in rape oil, from potato strips of all the samples. The first stage of frying involved the temperature of 175°C, frying time amounted 1 minute and the samples were subsequently cooled and frozen to the temperature of –18°C. The second stage of frying featured the temperature of 175°C and 5 minute frying time.

Dry matter was determined with the use of a dryer method, in potato strips previously subjected to blanching and pre-drying (to 24%, 26%, 28% and 30% of dry matter) and in French fries after first and second stage of frying [AOAC, 1995]. In French fries after I and II stage of frying there was determined fat content, according to Soxhlet method, throught sample extraction with diethyl ether using the device of Büchi Distillation Unit B-316 type.

Five minutes after frying French fries were subjected to mechanical properties measurement, *i.e.*: texture, shearing work and TPA test. The measurement was done with the use of measuring device of Instron 5544 type with Merlin software and using different attachments. To measure of French fries texture there was applied shearing attachment QTS-SB-25, which was moving at the speed of 250 mm/min. To conduct of TPA test a compressing plate was applied of 227 diameter. Each texture measurement involved collection of 15 French fries and shearing of each sample took place in the middle of their length. There was determined maximum shearing force F_{max} (N) needed to shear each sample, as well as work done to obtain this force value (shearing work Wt_{max}). TPA test measurement was repeated 6 times, each French fries underwent shearing twice (second shift of a moveable plate amounts 70% of basic height). On the basis of the test there were determined the select, following parameters: hardness, tenacity, springiness and gumminess.

Ten minutes after frying, French fries underwent organoleptic assessment according to a 5-point scale, as well as regarding their colour – using objective method based on measuring device Minolta Chroma Meter CR-200 type. Differences of samples colour were provided as CIE system with *L, a, b* coordinates, (value *L* – indicates lightness i.e.: the *L* value represents light-dark spectrum with a range from 0 (black) to 100 (white)., value *a* – measuring the colour of green-red range, value *b* – measuring the colour of blue-yellow range) [Minolta, 1994; Pomeranz & Meloan, 1994].

Statistical analysis. Results were analysed statistically using Statistica v.7.1 programme with one-way analysis of variance and multiple range test. There were determined homogenous groups and the least significant difference (LSD) according to Duncan's test (at significance level of $p \leq 0.05$).

RESULTS AND DISCUSSION

The process of pre-drying potato strips before frying results in the increase in French fries dry matter and therefore it can effect on their quality. In Table 1 there was shown dry matter content in French fries after I and II stage of frying, depending on the method and degree of pre-drying potato strips. It could be stated that depending on the degree of pre-drying potato strips, French fries dry matter increased after I and II stage of frying. Pre-drying potato strips within the range from 23% to 30% dry matter (*i.e.* decrease in moisture by 7%) caused the incerase in French fries dry matter, after their II stage of frying, predried using microwave method (480W) – by about 20%, while in the case of those pre-dried with other methods – average by 28%.

Fat content in French fries was one of determinants of their quality. On the basis of the results tabled in Table 2 it was proved that average fat content in French fries after I stage of frying, predried using microwave method (480W) was by about 4% lower in comparison to the samples pre-dried by microwave method (240W), by about 10% lower in the case of microwave method (720W) and by about 13% using convective metod. The lowest fat content featured half-product (French fries after I stage of frying) after pre-drying by microwave method (480W) – average 2.93% (9.09g/100g dry matter), while the highest value was obtained for pre-drying with the use of convective metod – average 3.35% (10.58g/100g dry matter). In ready French fries pre-dried acording to microwave method (480W) fat content was the lowest and amounted average 11.34% (18.69g/100g dry matter) and it was nearly 1.5 times lower than that of samples pre-dried by convetive method (Table 3).

Analysing the results in Tables 2 and 3 it can be recorded that fat content in French fries after I and II stage of frying showed a tendency to decreasing in relation to not pre-dried sample (control sample), regardless the method and degree of strips pre-drying. I was observed that alteration in strips dry matter

TABLE 1. The content of dry matter in French fries after stage I and II of frying as dependent on method and degree of pre-drying the potato strips.

Pre-drying method	Potato strips		Dry matter (%)	
	Pre-dying degree (%)	Dry matter (%)	French fries after stage I of frying	French fries after stage II of frying
Microwave (240W)	0	23	27.04	55.50
	1	24	28.40	57.36
	3	26	30.59	62.98
	5	28	33.02	64.19
	7	30	35.55	77.23
Microwave (480W)	0	23	27.04	55.50
	1	24	30.70	58.14
	3	26	33.20	59.11
	5	28	34.60	62.23
	7	30	37.31	68.98
Microwave (720W)	0	23	27.04	55.50
	1	24	30.80	58.15
	3	26	32.35	65.10
	5	28	33.30	69.90
	7	30	34.85	77.43
Convective	0	23	27.04	55.50
	1	24	31.15	65.10
	3	26	33.50	72.43
	5	28	34.30	73.96
	7	30	35.10	75.40

TABLE 2. The content of fat in French fries after stage I and II of frying as dependent on method and degree of pre-drying the potato strips.

Pre-drying method	Potato strips		Fat content in French fries	
	Pre-drying degree (%)	Dry matter (%)	(%)	(g/100 g s.m)
Microwave (240W)	0	23	3.11c	11.51d
	1	24	2.10a	7.39a
	3	26	2.60b	8.49b
	5	28	3.41d	10.33c
	7	30	4.07e	11.44d
Mean of pre-drying degree			3.05AB	9.83B
LSD			0.19	1.05
Microwave (480W)	0	23	3.11c	11.51c
	1	24	2.40a	7.82a
	3	26	2.83b	8.53b
	5	28	3.11c	8.99b
	7	30	3.22d	8.63b
Mean of pre-drying degree			2.93A	9.09A
LSD			0.09	0.65
Microwave (720W)	0	23	3.11b	11.51d
	1	24	2.92a	9.37ab
	3	26	3.05ab	9.10a
	5	28	3.40c	9.91b
	7	30	3.77d	10.74c
Mean of pre-drying degree			3.25AB	10.13BC
LSD			0.14	0.46
Convective	0	23	3.11b	11.51c
	1	24	2.73a	8.86a
	3	26	3.40c	10.51b
	5	28	3.55d	10.66b
	7	30	3.97e	11.39c
Mean of pre-drying degree			3.35B	10.58C
LSD			0.11	0.71
Mean of pre-drying method			3.14	9.90
LSD			0.35	0.72

difference letters (a,b,c,d,e) indicate significant differences among results of pre-drying degree ($p \leq 0.05$); difference letters (A,B,C) indicate significant differences among results of pre-drying method ($p \leq 0.05$); LSD – least significant difference

TABLE 3. The content of fat in French fries after stage II of frying as dependent on method and degree of pre-drying the potato strips.

Pre-drying method	Potato strips		Fat content in French fries	
	Pre-drying degree (%)	Dry matter (%)	(%)	(g/100 g s.m)
Microwave (240W)	0	23	11.81c	21.28d
	1	24	10.58a	18.44b
	3	26	10.88b	17.27a
	5	28	12.98d	20.22c
	7	30	15.56e	20.14c
Mean of pre-drying degree			12.36AB	19.47A
LSD			0.14	1.10
Microwave (480W)	0	23	11.81c	21.28d
	1	24	9.98a	17.16a
	3	26	10.23b	17.31a
	5	28	12.23d	19.65c
	7	30	12.45e	18.05b
Mean of pre-drying degree			11.34A	18.69A
LSD			0.15	0.27
Microwave (720W)	0	23	11.81a	21.28b
	1	24	12.35b	21.23b
	3	26	13.45c	20.66a
	5	28	13.69d	19.58a
	7	30	18.19e	23.49c
Mean of pre-drying degree			13.90BC	21.24B
LSD			0.15	1.25
Convective	0	23	11.81b	21.28b
	1	24	10.82a	16.62a
	3	26	15.12c	20.87b
	5	28	17.30d	23.39c
	7	30	20.13e	26.69d
Mean of pre-drying degree			15.03C	21.77B
LSD			0.15	1.15
Mean of pre-drying method			13.15	20.29
LSD			1.74	1.65

difference letters (a,b,c,d,e) indicate significant differences among results of pre-drying degree ($p \leq 0.05$); difference letters (A,B,C) indicate significant differences among results of pre-drying method ($p \leq 0.05$); LSD – least significant difference

TABLE 4. French fries colour (*L, a,* b – values) as dependent on method and degree of pre-drying the potato strips.

Pre-drying method	Potato strips		French fries colour		
	Pre-drying degree (%)	Dry-matter (%)	L	a	b
Microwave (240W)	0	23	56.07a	2.71a	30.82c
	1	24	53.00d	4.10bc	30.35c
	3	26	51.25c	3.30b	27.05a
	5	28	50.75b	3.40b	30.50c
	7	30	48.25a	3.70bc	28.50b
Mean of pre-drying degree			51.86A	3.44C	29.44A
LSD			0.22	0.45	1.25
Microwave (480W)	0	23	56.07b	2.71d	30.82c
	1	24	57.00c	1.09b	31.10c
	3	26	61.75e	0.40a	29.40b
	5	28	57.60d	1.33c	32.10c
	7	30	49.95a	1.01b	28.20a
Mean of pre-drying degree			56.47C	1.31A	30.32A
LSD			0.10	0.22	1.1
Microwave (720W)	0	23	56.07d	2.71c	30.82b
	1	24	56.75e	0.55a	28.16a
	3	26	55.00c	1.80b	31.85b
	5	28	51.55b	3.78d	33.18c
	7	30	50.75a	2.85c	27.70a
Mean of pre-drying degree			54.12B	2.33B	30.34B
LSD			0.17	0.90	1.11
Convective	0	23	56.07c	2.71c	30.82cd
	1	24	53.90a	5.85d	32.40d
	3	26	56.85d	0.40a	25.60a
	5	28	55.00b	1.10b	27.60b
	7	30	56.70d	1.95b	30.50c
Mean of pre-drying degree			55.70BC	2.40B	29.38A
LSD			0.18	0.68	1.85
Mean of pre-drying method			54.53	3.12	29.87
LSD			2.01	1.01	0.95

difference letters (a,b,c,d,e) indicate significant differences among results of pre-drying degree ($p \leq 0.05$); difference letters (A,B,C) indicate significant differences among results of pre-drying method ($p \leq 0.05$); LSD – least significant difference

amount ranging from 23% to 24% (*i.e.* dehydration by 1%) did considerably effect on fat content lowering in French fries pre-dried according to the examined methods (fat content showed the lowest, the most advantageous values). However, as the degree of strips pre-drying increased within the range from 26% to 30% (potato strips dehydration from 3% to 7%) fat content in semi-product and in French fries also did increase. Krokida *et al*. [2001b] and Mayano *et al.* [2002], report that drying of potatoes before frying using microwave and hot-air treatment has resulted in reduction in oil content of different products.

The application of strips pre-drying by different methods, before frying significantly effected on French fries colour. It was noted that depending on pre-drying metod determinant "*L*" value ranged from 56.47 to 51.87, as far as "*a*" determinat was concerned – the values amounted from 3.44 to 1.31, while "*b*" determinant showed the values from 29.44 to 30.34 (Table 4). On the basis of determinants *L*, *a* and *b* obtained it was possible to state that the lighnest (desirable) colour characterised French fries made of strips pre-dried by microwave method at power applied ranging (480W), while the darkest colour (the least desirable) featured French fries pre-dried by microwave method (240W). It was recorded that longer potato strips pre-drying, prior to frying, within the range from 26% to 30% of dry matter (increased strips dehydration from 3% to 7%), regardless pre-drying method, did considerably worsen the colour of ready product. The advantage of microwave pre-drying is the fact that this treatment alters dryied material colour only to a small degree, *e.g.* potato slices [Bouraoui *et al*., 1994], apples [Feng & Tang, 1998] or banana [Maskan, 2000] in comparison to pre-drying by convective method (with hot air blow) which results in significant worsening of product colour. Krokida *et al.* [2001a] investigated the effects of different drying methods on the colour of the obtained products. They found that colour characteristic are significantly affected by the drying methods and that the changes in "*a*" and "*b*" values. In paticular, air-, vacuum and microwave drying caused extensive browning in fruit and vegetables with a decrease in "*L*" value and an increase in "*a*" and "*b*" values improved colour characteristic.

TABLE 5. Organoleptic estimation (points 1-5) of French fries frying as dependent on method and degree of pre-drying the potato strips.

Potato strips		Pre-drying method			Convective	Mean results of organoleptic estimation (points 1-5)
Pre-drying degree	Dry matter	Microwave (240W)	Microwave (480W)	Microwave (720W)		
(%)	(%)	organoleptic estimation (points 1-5)				
0	23	4.3	4.3	4.3	4.3	4.3 b
1	24	4.5	4.5	4.6	3.9	4.3 b
3	26	4.0	4.7	4.5	4.0	4.3 b
5	28	4.3	4.3	4.6	4.1	4.3 b
7	30	4.0	4.5	4.3	3.6	4.1 a
Mean		4.2 B	4.5 C	4.4 BC	3.9 A	
LSD pre-drying degree						0.19
LSD pre-drying method				0.25		

difference letters (a,b) indicate significant differences among results of pre-drying degree ($p \leq 0.05$); difference letters (A,B,C) indicate significant differences among results of pre-drying method ($p \leq 0.05$); *LSD* – least significant difference

Basing on the results of organoleptic assessment (acording to a 5-points scale) of French fries, depending on potato strips pre-drying metod and its degree, it was stated that the method of pre-drying did considerably effect on French fries assessment (Table 5). French fries pre-dried by mirowave methods scored higher (from 4.2 to 4.5 points) in comparison to those pre-fried using convective method (3.9 points). Among French fries dried by microwave methods, higest were assessed the samples pre-dried at the power of 480W (4.5 points), while lowest assessment values were given to those pre-fried at the power of 240W (4.2 points). French fries pre-dried within the range of 23% to 28% of dry matter (*i.e.* decreased moisture by 5%), gained 4.3 points and only strips dehydration to 7% caused lower assessment – 4.1 points.

Frech fries texture measurement by the objective method enables determination of its characterisic mechanical properties, *i.e.* maximum shearing force (cutting) and cutting force [Figiel & Frontczak, 2001; Tajner-Czopek & Figiel, 2003]. On the basis of French fries texture assessment it was proved that as the degree of potato strips pre-drying before frying increases within the range from 24% to 30% of dry matter, French fries ecame harder and harder (Table 6) and the values of French fries maximum shearing force were also higher (Figure 1). It was reported significant effect of French fries pre-drying method prior to frying on the increase in ready product hardness appropriate texture featured french fries obtained from potato strips pre-dried by icrowave metod at 480W power applied – average 32.4 N. Those fries were of the best texture as compared to French fries dried by convective method – average 35.5 N (too hard). Texture is a meaningful factor deciding about French fries quality [Krokida *et al.,* 2001b] and therefore, potato strips pre-drying before frying should be conducted mainly by microwave method, with appropriately combined parameters and the possibility of eliminating pre-drying by forced convective method. Bushway *et al.* [1984] compared the texture of microwave pre-treated fries with convectional French fries and they noted an improvement of their texture caused by microwave pre-treatment.

TABLE 6. The texture of French fries as dependent on method and degree of pre-drying the potato strips.

Pre-drying method	Potato strips		Texture
	Pre-drying degree (%)	Dry matter (%)	(N)
Microwave (240W)	0	23	30.1a
	1	24	32.1b
	3	26	33.2bc
	5	28	34.1c
	7	30	36.9d
Mean of pre-drying degree			33.3AB
LSD			1.33
Microwave (480W)	0	23	30.1a
	1	24	31.2ab
	3	26	32.0bc
	5	28	33.5c
	7	30	35.3d
Mean of pre-drying degree			32.4A
LSD			1.59
Microwave (720W)	0	23	30.1a
	1	24	31.0a
	3	26	33.2b
	5	28	35.6c
	7	30	37.9d
Mean of pre-drying degree			33.5B
LSD			1.41
Convective	0	23	30.1a
	1	24	32.5b
	3	26	35.4c
	5	28	38.4d
	7	30	41.3e
Mean of pre-drying degree			35.5C
LSD			0.89
Mean of pre-drying method			33.67
LSD			1.05

difference letters (a,b,c,d,e) indicate significant differences among results of pre-drying degree ($p \leq 0.05$); difference letters (A,B,C) indicate significant differences among results of pre-drying method ($p \leq 0.05$); *LSD* – least significant difference

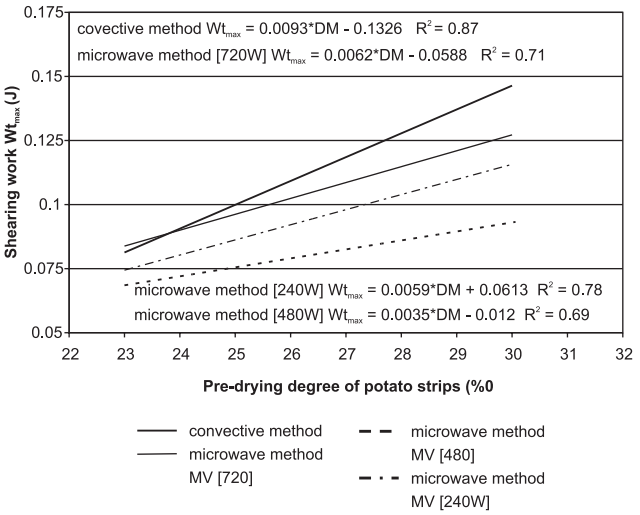

FIGURE 1. The shearing work of French fries as dependent on the degree and method of pre-drying the potato strips.

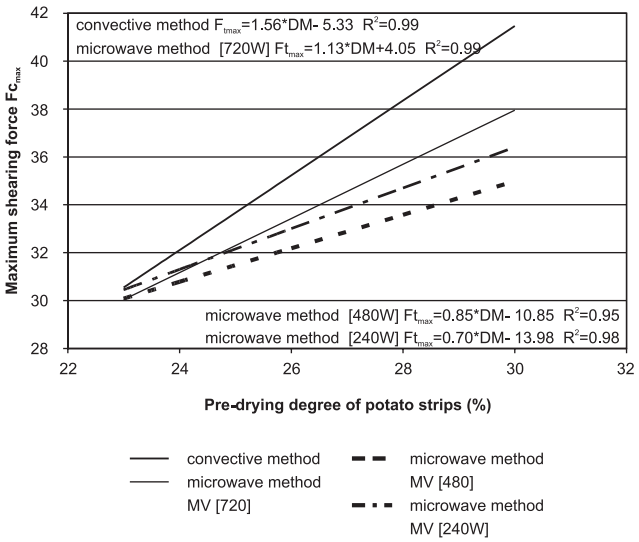

FIGURE 2. The maximum shearing force of French fries as dependent on the degree and method of pre-drying the potato strips.

TABLE 7. Chosen parameters of determination of the TPA test as dependent on the method and degree of pre-drying the potato strips.

Pre-drying method	Potato strips			TPA parameters		
	Pre-drying degree (%)	Dry matter (%)	Hardness (N)	Cohesiveness (mJ)	Springiness (mm)	Gumminess (N)
Microwave (240W)	0	23	142a	0.17a	2.34a	24.0a
	1	24	159a	0.19a	2.96a	35.6b
	3	26	189b	0.24b	3.66b	49.2c
	5	28	199b	0.31c	3.99bc	54.7cd
	7	30	216c	0.34c	4.30c	64.0d
Mean of pre-drying degree			181AB	0.25AB	3.45B	45.5B
LSD			16	0.03	0.63	10.7
Microwave (480W)	0	23	142a	0.17a	2.34a	24.0a
	1	24	145a	0.20a	2.97b	34.8b
	3	26	152b	0.29b	3.88c	41.9bc
	5	28	159b	0.35c	4.02c	49.6c
	7	30	162b	0.39d	4.39c	51.2c
Mean of pre-drying degree			152A	0.28B	3.52B	40.3A
LSD			11	0.03	0.62	11.0
Microwave (720W)	0	23	142a	0.17a	2.34a	24.0a
	1	24	159a	0.18a	2.89a	35.6b
	3	26	195b	0.21b	3.67b	48.4c
	5	28	210b	0.23b	4.12bc	56.2cd
	7	30	279c	0.31c	4.53c	60.3d
Mean of pre-drying degree			197B	0.22A	3.51B	44.9B
LSD			15	0.02	0.54	11.2
Convective	0	23	142a	0.17a	2.34a	24.0a
	1	24	198b	0.18b	2.79b	39.8b
	3	26	259c	0.22bc	3.09b	59.4c
	5	28	296cd	0.26c	3.54c	71.3cd
	7	30	335d	0.32d	4.39d	83.0d
Mean of pre-drying degree			246C	0.23A	3.23A	55.5C
LSD			45	0.04	0.43	14.5
Mean of pre-drying method			194	0.24	3.42	46.55
LSD			44	0.03	0.20	4.5

difference letters (a,b,c,d,e) indicate significant differences among results of pre-drying degree ($p \leq 0.05$); difference letters (A,B,C) indicate significant differences among results of pre-drying method ($p \leq 0.05$);
LSD – least significant difference

On the basis of the investigation conducted it was stated that the value of French fries shearing work increased as the degree of potato strips pre-drying before frying increased, within the ranged from 24% to 30% of dry matter (Figure 2). Shearing (cutting) work was strictly dependent on texture results (Figures 1 and 2). On the basis the results was stated that the lowest values of shearing work (from 0.07 J to 0.09 J) were obtained for shearing French fries made of potato strips pre-dried by microwave method at the power of 480W (proper texture 32.4 N), while the highest work values (the range from 0.08 J to 0.15 J) at congvective pre-drying (to hard texture – 35.5 N). Tajner-Czopek & Figiel [2003] stated that values of shearing work depended on the maximum shearing force (texture) of French fries, alterations of related data were directly proportional.

TPA test parameters enable accurate and thorough analysis of French fries texture. In Table 7 there were shown the results of determination of selected TPA test parameters (hardness, cohesiveness, springiness and gumminess) in French fries, depending on the method and degree of potato strips pre-drying. There was recorded considerable effect of potato strips pre-drying degree (within the range from 24% to 30% of dry matter) before frying on the increase in hardneness values cohesiveness, springiness and gumminess of ready product. French fries pre-dried by microwave method (480W} characterized the lowest hardness (average 152 N) and gumminess (average 40.3 N), and those values were 1.5 times lower as compared to those of French fries pre-dried by convective method. Microwave method at the power of 480W applied to French ries pre-drying did improve such parameters as cohesiveness (average 0.28 mJ) and their springiness (average 3.52 mm).

The results of both tests conducted – shearing resistance and TPA proved that appropriate texture belonged to French fries pre-dried by microwave method at 480W power, while too hard ready product was obtained after potato strips pre-drying by convective method. The pre-drying processes depend on the physical state of the material subjected to drying [Lewicki, 2006], and selecion of the method aims al the improvement of product quality. Microwave pre-drying has significant advantage than convective method, because microwave method is rapid, more uniform, convinient and more efficient compared with convectional hot air pre-drying [Wang *et al*., 2004] The products pre-dried using microwaves maintain appropriate colour, texture and taste. Should be remember that microwave pre-drying is know to results in a poor quality if not properly applied of parameters the microwave method [Drouzas & Schubert, 1996].

CONCLUSIONS

1. Pre-drying applied to French fries resulted in decreased fat absorption, during I stage of frying, regardless drying method used and more satisfactory results were obtained at dehydration by 1-3%.

2. French fries pre-dried by microwave methods characterized better organoleptic properties than the ones pre-dried by convective method.

3. French fries became harder as the degree of pre-drying of potato strips increased and pre-drying according to convective method proved to be the least advantageous for French fries texture.

4. Microwave drying at magnetrons power level 480W occurred to be the most appropriate method of French fries pre-drying before frying.

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WPŁYW METODY PODSUSZANIA FRYTEK ZIEMNIACZANYCH NA ICH JAKOŚĆ I WŁAŚCIWOŚCI MECHANICZNE

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Zastosowanie metody suszenia mikrofalowego w procesie podsuszania krajanki przed smażeniem, w zdecydowanie większym stopniu może kształtować jakość frytek, w porównaniu z metodami konwekcyjnymi. Celem pracy było określenie wpływu metody i stopnia podsuszania krajanki ziemniaczanej po blanszowaniu, na zawartość tłuszczu we frytkach oraz ich właściwości mechaniczne i organoleptyczne.

Na postawie badań stwierdzono, że podsuszanie frytek przed smażeniem wpłynęło na mniejszą chłonność tłuszczu, podczas pierwszego stopnia smażenia niezależnie od stosowanej metody podsuszania, przy czym lepsze rezultaty uzyskano przy odwodnieniu o 1-3%. Frytki podsuszane metodami mikrofalowymi charakteryzowały się lepszymi cechami organoleptycznymi, niż podsuszane metodą konwekcyjną. Wraz ze wzrostem stopnia podsuszania krajanki przed smażeniem otrzymane frytki były bardziej twarde, przy czym najmniej korzystnie na teksturę frytek wpłynęło podsuszanie metodą konwekcyjną. Suszenie mikrofalowe, przy poziomie mocy magnetronów 480W, jest najbardziej odpowiednią metodą do zastosowania przy podsuszaniu frytek przed smażeniem.