THE INFLUENCE OF PRE-TREATMENT METHOD ON THE FAT CONTENT DECREASE IN FRENCH FRIES

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Abstract

French fries are very popular product in many countries. But this product together with potato chips is included in the group of unhealthy products due to high content of fats, acrylamid, and peroxide value. Therefore the aim of this research was to evaluate the pre-treatment methods for reducing the fat content, and improving other quality parameters.

Before frying the potato strips were blanched in hot water at 85 °C, and dried in microwave-vacuum dryer for 3, 6 and 8 min, and in conventional dryer with air ventilation for 15 min at 60 and 80 °C, and 10 min at 100 °C temperature. The frying was done at 170 °C for 1.5–2 min. The colour (in CIE L*a*b*), texture (with texture analyser), the moisture content, the total fat content, and the ascorbic acid content were analysed for all prepared samples.

The best preliminary drying technology was drying in the conventional dryer at 100 °C temperature for 10 min. The product prepared with this technology had the lowest total fat content (3.4%) and the lowest hardness (lowest maximal cutting force: 11.3 N). The lowest moisture content was to sample dried in in microwave-vacuum dryer for 8 min (36.84%). This sample was also the hardest one (maximal cutting force: 52.41 N). There were no significant differences ($p>0.05$) in colour (L* a* b*) values between control samples and samples dried in conventional dryer but the samples dried in microwave-vacuum dryer became darker than control samples (lower L* value 57.37).

Keywords: French fries, preliminary drying, total fat content.

Introduction

French fries are very popular product in many countries. But this product together with potato chips is included in the group of unhealthy products due to high content of fats, acrylamid, and peroxide value.

High oil content is a major factor affecting consumer acceptance of oil-fried products today and the low fat food products are becoming more popular (Bunger, Moyano, Rioseco, 2003; Mai Tran et al., 2006). Oil consumption especially saturated fat is considered a major factor increasing health risks such as coronary heart disease (CHD), cancer, diabetes and hypertension, and even linked to increased causes of deaths. Fried foods contribute a significant proportion of the total fat consumed in the Western world. The fat content in French fries produced by different companies can vary between 3.4 and 20.9% (USDA National Nutrient Database for Standard Reference). That proves the influence of production technology and other factors to the total fat content of this product.

Knowledge of optimal frying conditions is important to produce French fries with low fat content, both under industrial conditions and at home.

During deep-fat frying, water in the crust will evaporate and move out of the food. In order for the flow of vapour to continue, sufficient water has to be able to migrate from the core of the food to the crust and the crust has to remain permeable. The fact that the vapour leaves voids for the fat to enter later, is the reason why fat uptake is largely determined by the moisture content of the food (Mehta, Swinburn, 2001). Similarly, sections of the food with more moisture loss also show higher uptake of fat. Some even argue that the total volume of fat will equal the total volume of water removed (mass balance) (Pinthus et al., 1993). An increase in the density of potato tuber also leads to a decrease in fat absorption. In one study of fried potato chips, tubers with a higher density (1.103 g cm^{-3}) yielded chips with lower fat content (42.1%) than slices with lower density of 1.093 g cm^{-3} (48.8% fat) (Ufheil, Escher, 1996). The thickness of the potato strips is an important factor affecting the overall fat content of French fries. Thick-cut strips (12 mm or bigger) absorb less fat than thin-cut strips (Blumentahl, 1991).

In the preparation of French fries, several processes are involved. The most common sequence is cutting – blanching – drying – pre-frying – freezing / chilling – packing – thawing. Each step may be important for the final product quality. The fat uptake varies with the pre-treatment of the potato. Blanching reduces the subsequent cooking time. Blanching also makes the colour more uniform after frying and it forms a layer of gelatinized starch that limits oil absorption and improves texture (Moreira, 1999).

Low temperature blanching enhances pectin methyl esterase (PME) activity and is another option proposed that affects both textural quality and oil uptake (Aguilar et al., 1999). Drying the surface of the potato strips before frying reduces the fat uptake in French fries. In the experiments of Lamberg et al. (1990) drying reduced the fat uptake by 7 to 29% (for 1 min frying) and by 15 to 40% (for 5 min frying). Drying causes a ‘skin’ to form on the surface of the potato strip and this reduces vapour transport through the surface layer. Raising the temperature of the fat higher than 185 °C causes the fat to break down more rapidly due to an increased rate of oxidation and polymer formation in the fat. When frying at 200 °C or above, excess energy in the fat is converted into cross-links leading to case-hardening of food. This results in a brown surface forming on the food before the inside is completely cooked and immersing the food for a longer time to cook the inside properly may cause burning on the outside (Blumenthal, Stier, 1991). In some countries maximum frying temperature is set at 180 °C. On the other hand, if French fries are cooked at lower temperature, or the 'boiling action' on the surface ceases due to a lower heat input, the crust does not form on the surface. This allows extra fat to penetrate into the core of the French fries. About 40% more fat is absorbed when the fat temperature is 10 °C lower than the recommended cooking temperature of 180 °C to 185 °C (Mehta, Swinburn, 2001).

The reducing of fat content in fried products is became as very actual topic of the research but there is still not a uniform opinion on the best solutions for reducing the fat content in fried French fries. There is a little information also about the influence of different pre-drying methods to the possible of the reducing of oil content in French fries. Therefore the aim of this research was to evaluate the pre-treatment methods for reducing the fat content, and improving other quality parameters.

Materials and Methods

The experiments were carried out in the laboratories of the Faculty of Food Technology, Latvia University of Agriculture. The potatoes of cultivar 'Laura' were used. The samples were cut into straws manually by hands 5×5 mm wide. Before frying the potato straws were blanched in hot water at 85 °C for 8 min, and dried in microwave-vacuum dryer MYCCOH-1 for 3, 6 and 8 min, and in conventional dryer with air ventilation for 15 min at 80 °C, and 10 min at 100 °C temperature. The frying was done at 170 °C for 2 min. The colour (in CIE L* a* b*), texture (with texture analyser), the moisture content, the total fat content, and the ascorbic acid content were analysed for all prepared samples.

Determination of textural properties

The textural properties of potato straws were measured in terms of the cutting force. A Texture Analyzer TA.XTplus (Stable Microsystems, UK) was used for cutting force determination. HDP/BSW blade set with Warner Blatzer was used for detection of cutting force to potato straws, moving at a test speed of 1.5 mm s^{-1} over a distance of 5.0 mm. The numerical results were expressed in N.

Total fat content

Determination of total fat content was occurred by using the SoxCapTM2047 in combination with Soxtec extraction systems. The total fat content was tested to samples, which were treated with oil, and with oil and water, but was not tested to samples treated only with water because of too low fat content.

Colour measurements

Colour of samples was measured in CIE L*a*b* colour system using Tristimulus Colorimeter, measuring Hunter colour parameters by Colour Tec PCM/PSM. Colour values were recorded as L* (brightness) – the vertical co-ordinate runs from L* = 0 (black) through grey to L* = 100 (white); a* (-a, greenness, +a, redness) – the horizontal co-ordinate, that runs from -a* (green) through grey to +a* (red) and b* (-b, blueness, +b, yellowness) – another horizontal co-ordinate, that runs from -b* (blue) through grey to +b* (yellow) (Coultate, 2002). The measurements were repeated on different randomly selected locations at the surface of each sample.

Total colour difference (ΔE*) between control sample and samples dried in different conditions was calculated using the following equation (1):

$$[\Delta E^*] = \sqrt{(L^* - L_0^*)^2 + (a^* - a_0^*)^2 + (b^* - b_0^*)^2} \quad (1)$$

where ΔE* – total colour difference; L*, a* and b* are the lightness (L), greenness (a) and blueness (b) values for the pre-dried samples; L_0*, a_0* and b_0* are the corresponding colour values for the control sample. The difference L*-L_0* is difference of lightness, a*-a_0* – difference of green and red colour and b*-b_0* – difference of blue and yellow colour.

The moisture content

Moisture content was determined using standard method ISO 6496:1999 by verified balance KERN (Germany) with precision ±0.001 g; mass loss calculation (%) were determined by weighing samples on the electronic scales, by standard LVS ISO 1442:1997.

The content of ascorbic acid

The content of ascorbic acid was determined by titration with 0.05-M iodine solution (Jansons, 2006). The French fries sample (25 g) were poured with 6% solution of oxalic acid and homogenized. Then the sample was filtered. 2 mL of 1% solution of starch was added to 10 mL of filtrate and the filtrate was titrated until the colour changed which does not disappeared during a 30 sec interval. For standard solution of ascorbic acid 20 mg of ascorbic acid were dissolved in 100 mL of the oxalic acid solution. Two mL of the starch solution was added to 25 mL of the standard-solution and the mixture was titrated. The content of vitamin C (ascorbic acid) mg per 100 g of the product dry matter was calculated with the following equation (2):

$$C = 5000 \cdot \frac{V_{sample}}{m \cdot V_{standard}}, \quad (2)$$

where V_{sample} – volume of the iodine solution titrated in a sample, mL;

$V_{standard}$ – volume of the iodine solution titrated in a standard solution, mL;

m – the amount of sample, g.

Statistical analysis

The results were processed by mathematical and statistical methods. One-way analyses of variance ($p \le 0.05$) were used to determine significance of differences between samples prepared by different drying methods in the main quality parameters: hardness, total fat content, colour (L* a* b*) and ascorbic acid content.

Results and Discussion

Textural properties

There were significant differences (p<0.001) in maximal cutting force between potato samples prepared with different pre-treatment methods. The samples dried in conventional dryer were with more similar textural properties comparing to control sample than samples dried in microwave-vacuum dryer (Fig. 1).

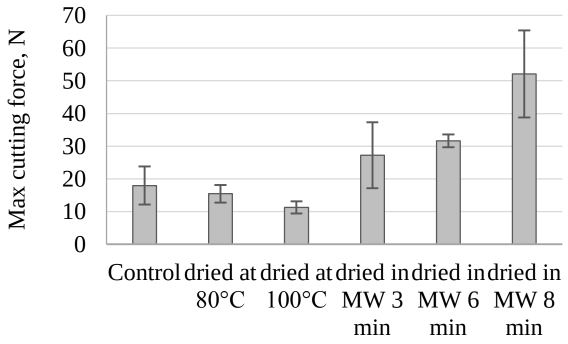

Figure 1. The texture of French fries pre-treated with different methods

The highest maximal cutting force was to French fries sample dried before frying in microwave-vacuum dryer for 8 minutes (in average 52.13 N) but the lowest maximal cutting force was observed to sample dried in conventional dryer at 100 °C temperature.

Total fat content

As the aim of these investigations was to find the method for production of French fries with the reduced oil content then total fat content of samples is very important quality parameter.

The total fat content of control sample (French fries blanched at 85 °C for 7 min, and just fried without drying) was in average 10.15% but in all samples, which were dried after blanching, the fat content was significantly lower (p=0.028) and didn't reach 8% (Fig. 2).

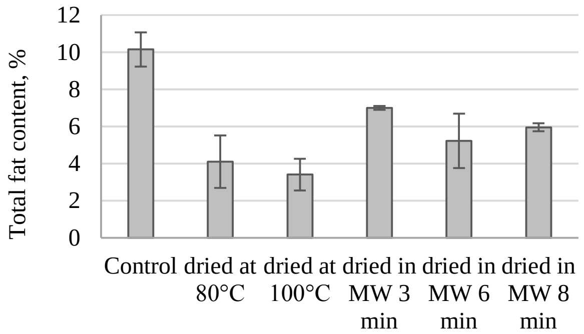

Figure 2. The total fat content of French fries pre-treated with different methods

The lowest total fat content was detected in samples dried in conventional dryer: in average 4.10% in samples dried at 80 °C, and 3.40% in samples dried at 100 °C. The samples dried in microwave-vacuum dryer contained higher amount of oil than conventionally dried samples. The effect of pre-drying to the oil content of French fries was found also by some other authors (Krokida et al., 2001). According to the results of these authors pre-drying pre-treatment had a significant effect on oil uptake and moisture loss, as well as structural properties of French fries. The use of air drying caused decreasing of the oil and moisture contents of French fries, while the porosity increased.

The colour L a* b* of different French fries samples*

Colour is another important factor in the qualified processing of French fries. The brown colour of potato chips is formed by a reaction between reducing sugars and amino acids. Brown colour of potato chips is formed when the moisture content decreases to below 6–12% (Mai Tran et al., 2006). Similarly the brown colour in French fries starts to form after rapid decreasing of moisture content in outside layers of potato strips. There were no significant differences found between samples in colour value a* (p=0.057), and value b* (p=0.338) but the brightness (L* value) significantly differed between samples (p<0.001) (Fig. 3).

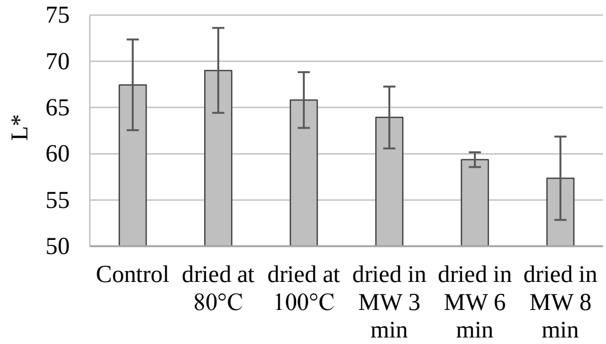

Figure 3. The brightness (L* value) of French fries pre-treated with different methods

The brightest was the sample dried at 80 °C temperature in conventional dryer (L*=69.01) but the darkest was the sample dried in microwave-vacuum dryer 8 min (L*=57.37).

In comparison with control sample the lowest total colour difference ΔE was observed also to sample dried at 80 °C temperature in conventional dryer but the highest colour difference ΔE was to sample dried in microwave-vacuum dryer 8 min (Fig. 4). Drying in conventional dryer does not change the colour of French fries while after drying in microwave-vacuum dryer the colour becomes darker. It could be explained with faster decreasing of moisture from the inside cells of potato strips. The authors Song et al., 2007 in the experiments with vacuum-fried potato chips with microwave-vacuum pre-drying also found that the vacuum-microwave pre-drying had a negative effect on colour of potato chips, which decreased the L* value of potato chips and increased Hunter a* and b* values.

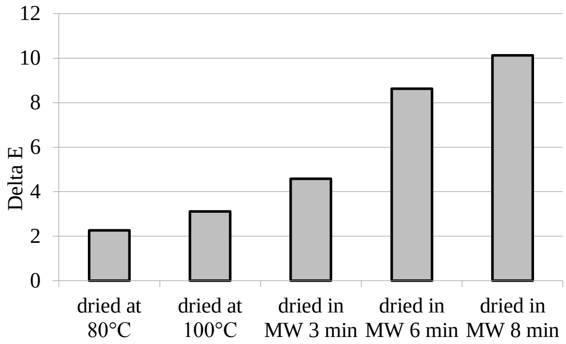

Figure 4. The total colour difference of French fries pre-treated with different methods

The moisture content

The moisture content of all French fries samples was similar, and there were no significant differences (p=0.21) found between samples pre-treated with various methods. But still there was tendency that samples dried in microwave-vacuum dryer for longer time contained lower moisture content than control sample.

The ascorbic acid content

The ascorbic acid content significantly differed between French fries samples (p=0.007). The highest ascorbic acid content was detected in sample dried in microwave-vacuum dryer 6 min. It was similar to control sample (in average 50.7 mg 100 g^{-1} of dry weight). The higher ascorbic acid content in microwave-vacuum dried potato products was detected also by other authors (Khraisheh, 2004). Our investigations with different fruit and vegetables showed higher retention of ascorbic acid after microwave-vacuum drying process compared to conventional air drying, too (Galoburda et al., 2012; Sne, Kampuse, 2011; Dorofejeva et al., 2011). The sample with the lowest ascorbic acid content was French fries dried in conventional dryer at 100 °C (in average 38.09 mg 100 g^{-1} of dry weight) (Fig. 5).

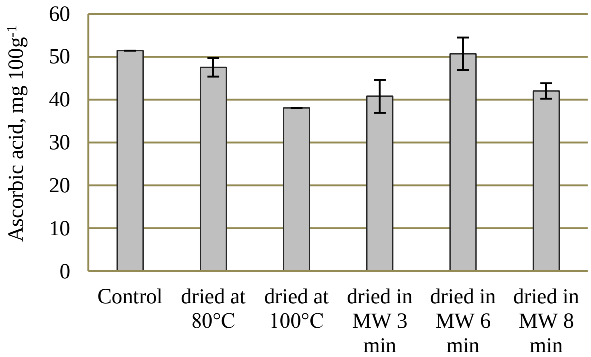

Figure 5. The ascorbic acid content of French fries pre-treated with different methods

With lowering the drying temperature in conventional dryer it was possible to save higher amounts of ascorbic acid – the French fries dried at 80 °C contained in average 47.56 mg 100 g^{-1} of dry weight ascorbic acid. The influence of temperature to the content of ascorbic acid in conventionally dried cranberries was proved also by investigations of Dorofejeva et al. (2010) where ascorbic acid content in cranberries rapidly decreased by rising temperature. But in experiments with red pepper scientists found that both vitamin C content and the total phenolic content decreased as air-drying temperature decreased (Vega-Gálvez et al., 2009). It means that processes of vitamin C degradation during drying can be influenced by the type of product and many other factors.

Conclusions

The drying in conventional dryer provided better quality parameters in the end product than drying in microwave-vacuum dryer. The lowest total fat content in French fries can be reached by drying in conventional dryer at 100 °C, but the lowest colour difference ΔE and the most similar cutting force to the control sample can be provided by drying in conventional dryer at 80 °C temperature.

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