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A new technique to evaluate the effect of chitosan on properties of deep-fried Kurdish cheese nuggets by TOPSIS

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ABSTRACT

Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) method was used to comprehensively evaluate physicochemical properties of fried cheese nuggets so that chitosan (0, 0.5 and 1.5%) was added to batter formulation under different processing conditions namely frying temperature (150, 170 and 190 °C) and time (0–4 min). A non-destructive, image-based method was used to measured mechanical properties of fried, breaded cheese nuggets. The results of this study indicated that all the batters have shear-thinning behavior and the coating pickup was found to be directly proportional to batter viscosity. The highest reduction in oil uptake (22.7%) was observed in samples contain 1.5% chitosan. The deep fried cheese nuggets containing chitosan tended to be higher in hardness and maximum sound peak and lower in porosity in comparison to the control sample. The optimum conditions resulting in desirable physico-chemical properties and minimum oil uptake were cheese nuggets with chitosan content of 1.5%, fried at a temperature of 170 °C for 4 min.

1. Introduction

The popularity of the frying process can be attributed to certain features of fried foods. Fried foods have good odor and visual appeal due to the golden brown color (Albert & Mittal, 2002; Dogan, Sahin, & Sumnu, 2005). However, one problem in connection with batter-fried foods is the significant amount of oil absorption during frying (Salvador, Sanz, & Fiszman, 2005). The development of methods to produce fried products with less oil uptake during frying is one of the main research fields in food science and technology (Sahin & Sumnu, 2009).

Several approaches have been suggested for decreasing oil uptake during frying of battered foods. Studies have shown that using edible films is a promising option to improve the overall quality of fried foods and also to optimize the temperature and time of frying (Albert & Mittal, 2002). Chitosan is a poly-β-(1 → 4)-2-amine-deoxy-D-glucopyranose and a naturally occurring component in shells of crustaceans and the cell walls of fungi. Special functional properties include antimicrobial activity (Tsai & Su, 1999), serum cholesterol lowering ability (Tsai & Su, 1999) and emulsification. In addition, chitosan cannot be digested and absorbed in human intestine and therefore it can be regarded as a dietary fiber (Lin & Chao, 2001).

Porosity is an important physical attribute of food products that is still mostly measured using manual methods with special devices such as mercury porosimetry and helium pycnometry, which are destructive, laborious, and inherently subjective (Adedeji & Ngadi, 2010). Thus such methods cannot provide sufficient information about pore structure characteristics but visual approach is an effective way to obtain the texture features (Qiao, Wang, Ngadi, & Kazemi, 2007). Image processing has already been successfully used in food quality inspections (Du & Sun, 2006; Qiao et al., 2007). It is a rapid, non-destructive and low-cost mean of assessing quality of food products.

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Since the demand for high quality and healthy food is globally increasing, in this study a comprehensive evaluation of the physico-chemical properties of fried Kurdish cheese nuggets was performed by using Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) method which was established in order to tackle problems in multiple criteria decision making (Sun, Liang, Shan, Viernstein, & Unger, 2011). The basic genuine is that the chosen alternative should have the shortest interval from the positive ideal solution and the farthest distance from the negative ideal solution (Zhu, Wang, Liang, Li, & Sun, 2012). The TOPSIS is a powerful method to evaluate several selected cases (such as formulation and frying conditions) to identify a suitable design formula.

The main objective of this study was to evaluate physico-chemical properties of fried cheese nuggets using TOPSIS method.

2. Materials and methods

2.1. Core part and coating layer preparation

In this study a Kurdish cheese was used as the core part of the product and then it was coated by batters with different formulation in laboratory of food science, Ferdowsi university of Mashhad. The characteristics of wheat flour and Kurdish cheese are presented in Table 1. A control batter was prepared by mixing wheat flour (90.8%), baking powder (3.1%), flavoring (pepper) (0.6%), and salt (5.5%). To determine the effects of chitosan on deep-fat-fried cheese nuggets, chitosan (sigma, low molecular weight) (0, 0.5 and 1.5%) were replaced with the same amount of wheat flour. The water/dry mix proportion was always 1.2:1 (w/w). The ingredients were mixed in a mixer (Moulinex, type BM4) for 2 min. The dimensions of the cheese nuggets were 4.5 cm (diameter) × 1.5 cm (thickness) ±0.2 cm. Cheese samples were immersed individually into the batter suspensions for 30 s and allowed to drip for 30 s.

2.2. Frying

Frying was performed in thermostatically temperature-controlled fryer (Black and Decker, Type 01) containing 1.5 L refined sunflower oil (Nina, Iran). Three samples were placed in a wire basket and then submerged for 0, 1, 2, 3 and 4 min at 150, 170 and 190 °C. Then, samples were allowed to drain for 30 s before being blotted gently with dry tissue paper to remove excess oil on the surface.

2.3. Rheological measurements

The flow behaviors of the batters were investigated at 25 ± 1 °C with a Bohlin rotational viscometer (Bohlin Model Visco 88, Bohlin Instruments, UK) with using proper spindles (C14, C25 & C30) according to viscosity of the samples. The sample was sheared at programmed rate linearly increasing from 14.2 to 400 s^{-1}.

Table 1
Chemical composition of Kurdish cheese and wheat flour used in the study.

(%)	Kurdish cheese	Wheat flour
Ash	7.83 ± 1.23	0.65 ± 1.85
Dry matter	46.93 ± 3.45	83.21 ± 4.25
Protein	36.23 ± 2.12	8.54 ± 1.94
Fat	34.81 ± 1.09	1.32 ± 0.36
Water	54.07 ± 3.02	13.71 ± 0.35

Values are mean ± SD (n = 3).

2.4. Batter pickup

The amount of batter adhering to the sample during immersion coating prior to frying was considered as the batter pickup and calculated as:

$$Batter\ Pickup(\%) = \frac{W_b - W_N}{W_N} \times 100 \quad (1)$$

W_b: the weight of the sample after immersed in batter
W_N: the weight of the sample before immersed in batter

2.5. Moisture content analysis

The coating and core portions of the cheese nuggets were carefully separated by hand for moisture and oil content analysis. Samples were dried in a conventional oven (Memmert, 154 Beschickung loading, model 100–800) at 105 °C for 24 h. The samples were cooled in desiccators and moisture contents were determined by difference in weight in terms of dry basis (AOAC, 1990).

2.6. Oil extraction

Oil content was determined by the Soxhlet method using AOAC official method 991.36 (1996). The dried samples used for moisture content determination were subsequently grounded in a blender (Nasional, K039131). The ground sample (2–4 g) was weighed and placed in a thimble. Oil was extracted in solvent extractor using petroleum ether (Extra pure, ET0091). The timbels were further dried at 105 °C for 60 min to remove residue solvent and moisture. Then the timbels were cooled in a desiccator and subsequently weighed. The oil contents were obtained in terms of dry basis.

2.7. Texture and acoustic analyses

Crispness of the fried cheese nuggets was evaluated by studying the sound emitted during fracture by simulating a human bite. Texture of the cheese nuggets was measured 30 min after frying, using a texture analyzer (QTS25 CNS; Farnell, UK) interfaced with a personal computer, measuring the acoustic emission simultaneously with a penetration test. A Blade probe was attached to the instrument for the penetration test. The test settings were: test speed 120 mm/min, trigger force 10 g, travel distance of the probe 7 mm. The microphone was positioned at 3 cm distance and with an angle of 0° to the sample. The samples were placed on an aluminum plate with a hole (HDP/CFS Crisp Fracture Support Rig) to allow the probe (ball P/0.25 s) to pass through after punching the sample. From the force and acoustic signals the maximum sound peak (dB), maximum force (N) and the number of total sound peaks were obtained. Extensive analysis of the sound was performed using MATLAB (Mathworks, v7. 5.0., USA) as described by Castro-Prada, Primo-Martín, Meinders, Hamer, and Van Vliet (2009).

2.8. Image processing

In order to investigate the effect of the chitosan, temperature and time frying on variations color and porosity of the cheese nuggets by image processing, the following procedure was applied: