PROFESSIONAL PAPER

Influence of Frying Time and Addition of Rice Starch on Oil Uptake and Textural Properties of Fried Coated Chicken Meat

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Summary

Rice starch in shares of 6, 8 and 10 % was used as replacement for eggs in the coating mixtures used for coating of meat before frying. After frying of meat at 170 ^{0}C for 4, 6 and 8 minutes, effects of frying time and addition of starch on oil uptake and meat texture were evaluated. Instrumental texture analysis of fried coated chicken meat was conducted, as well as Soxhlet method for determining of oil content in samples. Statistical analysis of relevant texture properties of fried meat was performed. Hardness of fried meat samples decreased with increase of the starch content in mixture. Elasticity of meat increased as a result of coatings water holding capability and consequent prevention of meat drying. Oil content in samples coated with mixtures containing rice starch decreased with increase of starch share. Optimal frying time was 6 minutes, which with 10 % of mass share of rice starch produced samples with 35.54 % less oil.

Keywords: texture analysis, hardness, elasticity, rice starch, frying

Sažetak

Rižin škrob u omjerima od 6, 8 i 10 % koristio se kao zamjena za jaja u smjesama za oblaganje mesa prije prženja. Nakon prženja na 170^{0}C tijekom 4, 6 i 8 minuta, ispitivan je utjecaj vremena prženja i količine škroba na upijanje ulja i teksturu prženog mesa. Obavljena je instrumentalna analiza teksture pohanog mesa, kao i metoda po Soxhletu za određivanje količine ulja u uzorcima nakon prženja. Provedena statistička analiza relevantnih teksturnih svojstava prženog mesa pokazala je značajno smanjenje tvrdoće mesa sa porastom udjela rižinog škroba u smjesi. Elastičnost mesa se povećava zahvaljujući zadržavanju vode i sprečavanju isušivanja mesa. Količina upijenog ulja manja je kod uzoraka obloženih smjesom koja sadrži rižin škrob, te se smanjuje dodatnim povećanjem njegovog udjela. Optimalno vrijeme prženja bilo je 6 minuta, što uz 10 %-tni udio škroba u smjesi dovodi do 35.54 %-tnog smanjenja količine ulja u uzorcima.

Ključne riječi: analiza teksture, tvrdoća, elastičnost, rižin škrob, prženje

Introduction

Texture is one of basic sensory properties which have influence on colour, nutritive value, and overall affect quality attributes of foodstuff. (Brnčić et al., 2008; Thybo et al., 2004). Visual examination and later mastication of fried chicken coated in various coating mixtures reveals differences in texture and colour, which significantly affect consumers' opinion and their buying decisions. Crust developed during frying (measured as crunchiness in texture analysis) is also highly appreciated by consumers (Sosa-Morales et al., 2006; Drewnowski et al., 1997). Hardness (or firmness, used by some authors specifically for hardness of meat) is in this case defined as force needed for penetration in meat sample. In relation to sensory tests, this is force needed for molar tooth to break a sample during mastication, or force of first bite. Large values for hardness correlate to firm samples which are not very well accepted by consumers. This is also case with the other extreme, too soft sample. So as fried meat must satisfy consumer expectations, hardness of analyzed coating mixture must fall in the strict range of values. Elasticity of meat is usually tightly related to hardness, and it represents maximum distance of probe travel before break of sample. It is also important factor, as too tough or elastic meat sample is not adequate for consumption.

Aside from the change of meat sensory and textural properties, coatings act as solute and gas barriers, and consequently have significant influence on oil uptake and water loss during frying. Microscopic image of one of the coating mixture formulations before frying is presented in Figure 1.

Rice starch was used as a substitute for eggs which act as a binding agent between meat and coating particles. By eliminating eggs from the list of ingredients in coating formulations, final product have better nutritive characteristics, which include less cholesterol and fat content. At the same time, safety of food is greater and shelf life is increased. As starch become one of the main ingredients in coating formulations, its type and gelatinization during frying play an important role in the texture of fried product. Increase of adhesivity of coatings to meat consequently increases mass of coating and surface coverage on the final meat product after frying.

Extruded corn flour has also been used as a binder which improves hardness and elasticity of fried coated meat, and in lesser extent on other textural properties. Coating act as a sealant, treating of meat preserve its nutritional value, moisture and weight loss, while improving juiciness and elasticity (Ahamed et al., 2007).

Addition of dietary fibers which consist mostly of non-starch polysaccharides (cellulose, hemicelluloses, etc.) further

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Figure 1. *Sample microscopic image of particles in mixture.*

enhance nutritive and health benefits of coating mixtures. Fibers contribute to lipid metabolism, stool volume and decrease risk of stomach and colon cancers. Some researches claim that fibers also reduce risk of cardiovascular diseases (Langkilde et al., 1993; Overton et al., 1994)

This paper will show if addition of rice starch to coating mixtures will fulfill this task and at the same time decrease the energy content of food by decreasing the oil content. At the same time, investigation of the influence of frying time on oil absorption and textural properties of coated meat samples was conducted.

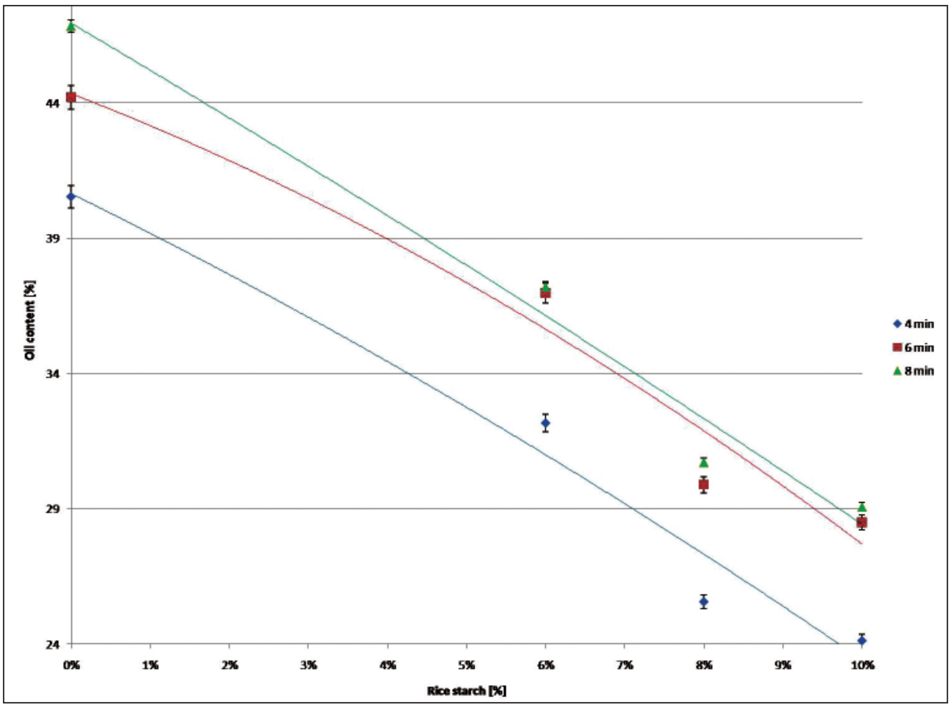

Figure 2. *Dependence of oil content on rice starch share in coating mixture.*

Materials and methods

Coating mixtures were prepared from extruded corn flour (Naše klasje d.o.o., Croatia) and rice starch (Pen-prom d.o.o, Croatia) which were homogenized in Retsch NM 301 homogenizer. High ester Grinsted XSS pectin on the citrus base (Danisco A/S, Denmark) and Fibrex (Danisco A/S, Denmark) were used in coating mixtures. Mixture of coriander, curry, white pepper, black pepper, chili, ginger, rosemary, paprika, marjoram, garlic and cardamom was used for improving of organoleptic properties of product. As a frying medium, palm oil was used (Zvijezda d.o.o., Croatia). Fresh de-boned chicken breast meat (pectoralis major) was purchased from a local supplier. The samples were stored in a freezer at (-18^{0}C) until used, and were thawed in a refrigerator at 4^{0}C for 24 h prior to use.

Chicken breasts were sliced on pieces with dimensions of 3 cm x 3 cm and 1 cm (±10 %) of thickness. Meat was uniformly coated in mixtures presented in Figure 1 and left on room temperature until frying (maximally 15 minutes). Frying was conducted using deep fat fryer on 170°C for 4, 6 and 8 minutes. After drying and cooling of samples on room temperature, instrumental analysis was conducted. Oil was changed after frying every batch of samples, and mass ratio of meat in oil was 100 g in 3000 g (3167 mL) (Christensen et al., 2000; Bejerholm and Aaslyng, 2003; Saguy and Dana, 2003). All measurements were repeated three times, and statistic analysis of obtained data was conducted. For the purpose of texture analysis, additional 3 samples were tested raw.

Table 1. *Composition of coating mixtures*

Mixture	Rice Starch [%]	Extruded corn flour [%]	Dietary fibers [%]	Spice mixture [%]	Salt [%]
SP	0.0	61.0	9.0	18.0	12.0
R1	6.0	55.0	9.0	18.0	12.0
R2	8.0	53.0	9.0	18.0	12.0
R3	10.0	51.0	9.0	18.0	12.0

Hardness and elasticity of samples were analyzed using texture analyzer (Stable Micro Systems, TA.HDPlus, Great Britain). Hardness is in this case defined as force needed for full penetration in the sample, and analyzed using the blade set. Depth of penetration was set at 5 mm, time of penetration at 25 s (penetration speed was consequently 0.2 mm/s). Elasticity of fried samples was tested using the P/6 steel probe with flat tip. Penetration depth was set at 15 mm to ensure penetration of probe through full depth of sample. For elasticity, maximum force applied for breaking of surface and penetration in

Table 2. *Oil uptake [%] in fried samples during various frying times.*

Frying time [min]	Rice starch share [%]			
	0	6	8	10
4	40.53 ± 0.42[1]	32.17 ± 0.19	25.57 ± 0.15	24.13 ± 0.21
6	44.21 ± 0.37	36.97 ± 0.22	29.89 ± 0.15	28.50 ± 0.27
8	46.84 ± 0.20	37.21 ± 0.28	30.73 ± 0.18	29.08 ± 0.26

[1] Standard deviation based on 3 analyzed samples

sample, as well as depth of penetration before breaking were measured (Cavitt et al., 2005).

Soxhlet method was used for measuring of the oil content in samples. Samples were weighted before and after 5 hours of continuous extraction using organic solvent. Oil content

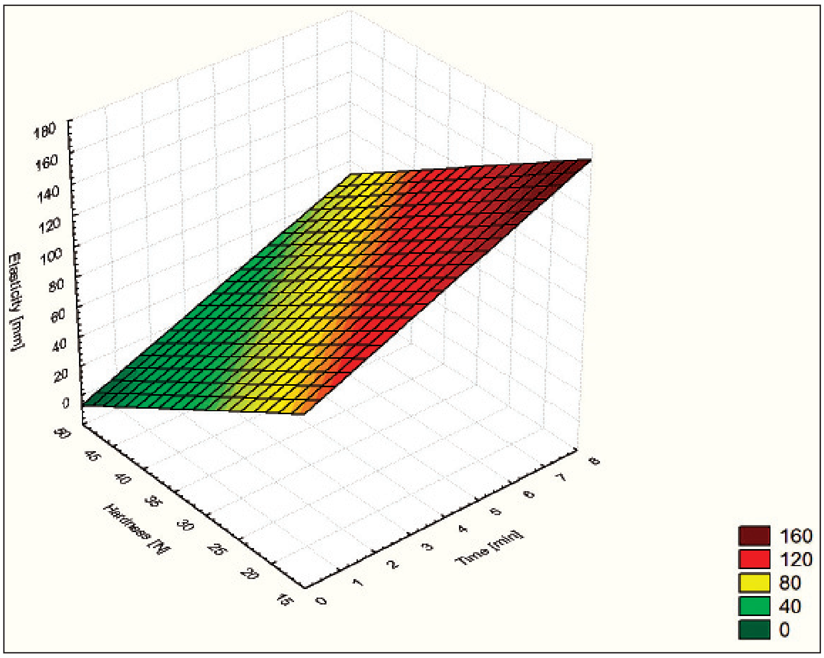

Figure 3. *Correlation between frying time and textural properties of samples*

was calculated for every sample using following standard equation:

$$\%(\text{oil content}) = \frac{(b\text{-}a)\cdot 100}{m} \qquad (1)$$

where:
a – mass of empty flask [g]
b – mass of oil filled flask [g]
m – mass of sample [g]

ANOVA statistic analysis was conducted using Statsoft Statistica software, with 3D surface plots for presentation of gathered data.

Results and Discussion

Oil absorption

Increase of rice starch share in coating mixtures leads to rapid decrease of oil content in fried samples, as seen in Figure 2. Minimal amount of oil (24.13 %) was absorbed with 10 % of rice starch present in the mixture. Samples without added rice starch show largest oil uptake for all frying times (up to 46.84 %). Evidently, increase of rice starch content decrease amount of absorbed oil for 37.91 %, which is significant from nutritive, health and sensory aspects. Evidently rice starch exhibit good film barrier forming capability, which leads to decrease of water loss during frying. This prevents absorption of larger amounts of oil into sample, which is further reinforced with pore diameter decrease during frying of the meat (Garcia el al., 2002).

Oil uptake amount presented in Table 2 is smallest in samples fried for 4 minutes. Unfortunately this frying time appear to be too short for analyzed samples, which can be seen in their texture characteristics presented in Figure 3, as well as in sensory tests. Oil absorption in samples continues to increase to 32.17 % after 6 minutes of frying. Further prolonging of frying time increase shrinking of samples and consequently sample surface area and number of closed pores, which prevent any further evaporation of water. This effectively stops additional absorption of oil (Pinthus et al., 1995). Based on analyzed data with $p = 0.018$, frying time of 6 minutes was optimal for samples, independently of mass share of rice starch in mixture. Together with maximal amount of starch used (10 %) those are optimal conditions for frying of the coated meat, regarding to oil uptake and textural properties of fried samples.

Texture analysis

Hardness of samples presented in Figure 3 linearly correlate with their elasticity and increase with frying time ($p<0.05$). After 8 minutes of frying, hardness is in excess of 45 N, which is

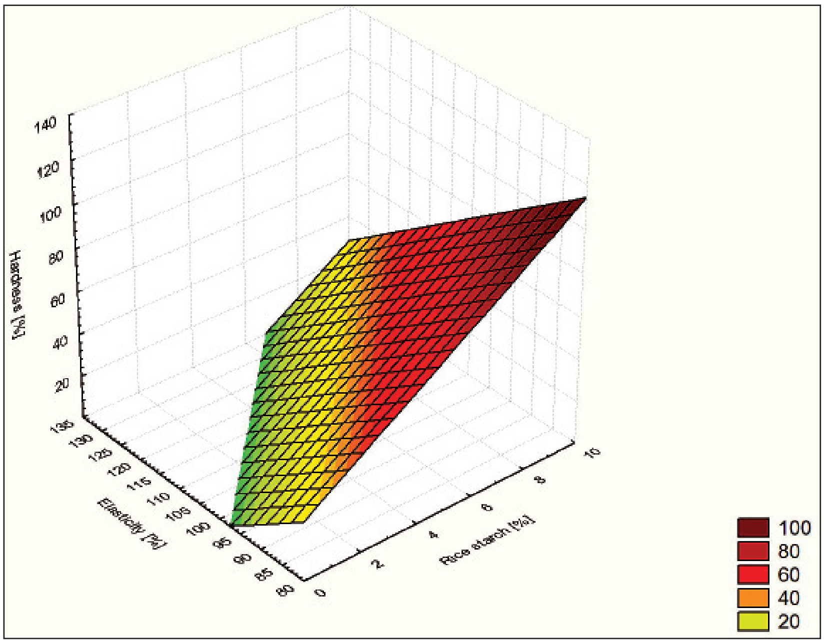

Figure 4. *Correlation between mass share of rice starch, hardness and elasticity of samples.*

on the upper border in correlation to sensory analysis. Samples fried for 8 minutes are still good enough from consumer perspective, but in relation to slightly increased oil uptake and significant increase of hardness, shorter frying time is preferred. However, at 4 minutes of frying samples were too soft, and still not enough fried. It turns out that 6 minutes was optimal duration of frying, based on the analysis of hardness.

Values for elasticity also increase with increase of time. In this case 6 minutes is also optimal duration of frying.

Increase of hardness and elasticity related to increase of rice starch mass share in coatings can be seen in Figure 4. Even on maximal rice starch content, values for hardness amount to 36.23 N, which is still in the acceptable range. From this it can be concluded that 10 % mass share of rice starch is acceptable for use in the coating formulation.

Conclusions

While lowest amount of oil is present in samples fried for 4 minutes, frying times shorter than 6 minutes were not sufficient for the production of good enough samples for consumption. Prolonging of frying time over 6 minutes just produced harder samples, with increased elasticity and no additional benefits. Based on the oil absorption and texture analysis data, 6 minutes at 170 ºC is optimal frying time for coated samples. As increase of rice starch share in coating mixtures lead to decrease of oil uptake, meat coated with mixtures containing 10% of rice starch absorb lowest amount of oil.

From consumer aspect, analyzed coatings should be preferred over standard mixtures currently on the market. Removing of eggs from mixtures; addition of optimal share of rice starch and dietary fibers leads to production of healthier, nutritionally improved and sensory acceptable coating mixtures for chicken.

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