Iranian Food Science and Technology Research Journal
Vol. 13, No. 1, Apr. May. 2017, p. 92- 104

نشریه پژوهشهای علوم و صنایع غذایی ایران
جلد ۱۳، شماره ۱، فروردین-اردیبهشت ۱۳۹۶ ص.۱۰۴-۹۴

Mechanical study for texture degradation of potato strip during frying process

H. Sabbaghi[1], A. M. Ziaiifar[*2], M.Kashaninejad[3]

Received: 2015.07.12
Accepted: 2016.01.25

Introduction: Texture is one of the most important attribute in foods and is always issues for the manufacturing of fried products, because texture plays a crucial role in consumer acceptance and the perceived quality of foods. Prediction of changes in texture during frying can be helpful in process control. Structurally, this quality parameter in fried potato strip made from the formation of a composite structure with two layers as: dry and oily outer layer (crust), and a moist or soft interior layer (core). So, the explanation of texture development during frying is difficult because of the innate heterogeneity of the fried potato tissue. Moreover, both thermal degradation and texture development are functions of variables such as processing time, oil temperature and vaporized moisture of product. Textural changes during frying described as the result of various physical, chemical, and structural changes involved in the frying process. One solution to reduce the complexity of real bio systems in engineering is using various empirical correlations. Application of these relations for prediction of textural changes during frying can help us for understand the proper conditions to achieve desired texture. The purpose of the present investigation was to study the influence of the frying temperatures on texture of potato strips. In fact, textural changes during various stages of frying potatoes including initial heating, surface boiling and falling rate period were investigated. Texture evaluation is done by mechanical measurements, because the stimulus in texture perception is mainly mechanical. Also, textural studies are not clearly performed up to now with focus on cook value as a main factor in potato frying. According to the definition of cook value, this parameter indicates total time of baking in 100 °C. Fractional conversion applied as a technique for analyzing texture degradation kinetics and softening of vegetables upon prolonged heating. A few assumptions were made during study: i) Potato shrinkage is neglected ii) Product is not completely dried iii) The stages of frying were considered separable only based on surface and center temperature iv) Texture of potato strips affected by cook values of each frying stages.

Materials and methods: The potato strips with specified size fried at a constant temperature of 145, 160 and 175 °C for 30, 60, 90, 120, 150, 180, 210 and 240 seconds. Then, various stages of the process were separated using surface and center temperature profiles of product that were recorded by data logger and T-type thermocouple in computer. Heating extremity of each stage was determined using cook value parameter. Mechanical properties such as apparent modulus of elasticity (Secant modulus) and toughness were used to show which occurred during frying. The secant modulus (S) variations described using fractional conversion model. The degree of cooking for each sample was expressed in term of cook value and its relationship with the overall acceptance of product was examined. Finally, the suitable temperature was determined by sensory evaluation to achieve the desired texture to determine the proper cook value and to prevent over cooking of product.

Results and Discussion: The stages of frying by immersion for experimental conditions can be divided as: I. Initial heating (The first 30 seconds for all oil temperature) II. Surface boiling (30-60 s). III. Falling rate (up to end, longest period). IV. Bubble end point (not considered). Generally, higher oil temperature showed larger center and surface cook values because of the fast temperature increase inside product. During initial heating period (I) because of temperature increase without boiling, the changes in cook values versus time are negligible. Surface cook value increased slowly compared with core during surface boiling. Maximum cook value for core temperature was higher, because of the vapor pressure at the center of the product and thus water evaporation at temperatures above 100 °C (cook value above 1 second). During falling rate period due to gradual reduction of evaporation rates, and thus the vapor pressure drop within product, boiling temperature reduced to 100 ° C. The

2 , 2 and 3- Ph. D. Candidate, Associate Professor and Professor of Food Processing Engineering, Gorgan University of Agricultural Sciences & Natural Resources
(*Corresponding author: ziaiifar@gmail.com)

major part of texture destruction occurred during initial heating period and the changes of textural characteristic were going to be constant at the end of surface boiling. The slope of the regression line for fractional conversion model decreased as temperature increased and therefore product was harder, but equivalent value of secant modulus was independent of process temperature. The consumer texture desired was found for temperature of 160 °C with medium cook value. The kinetics of potato softening followed an exponential decay equation with good correlation on empirical data. The temperature dependence of the degradation rate was reliably modeled by the Arrhenius equation. Activation energy (E_a) for model parameters S_e and Ks was 13047.12 and -24949.74 J/mol, respectively. Negative E_a for kinetic constant (K_s) indicated an inverse relationship with oil temperature. In addition, elevated oil temperatures caused less softening of French fries because of higher cook value and thus higher evaporation rate.

Keywords: Texture, Potato strip, Frying, Cook value, Secant modulus, Fractional conversion.