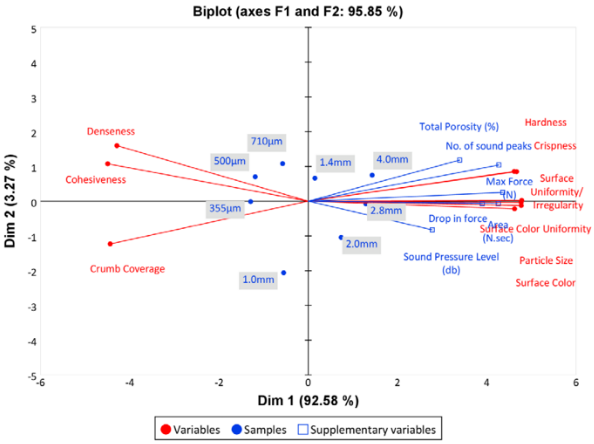
Understanding and predicting sensory crispness of deep-fried battered and breaded coatings

Kha Yiu Voong, Abigail Norton-Welch,[1] Thomas B. Mills,[1] and Ian T. Norton

Abstract

Crusted crispness refers to coatings with a dry and brittle surface contrasting a high-moisture core; it is desirable for the enjoyment and quality of deep-fried goods. This study aims to investigate instrumental measurements and sensory measurements of crispness. Deep-fried breadcrumb coatings of eight sizes were investigated: 4.0 mm, 2.8 mm, 2.0 mm, 1.4 mm, 1.0 mm, 710 µm, 500 µm, and 355 µm. Sensory profiling was carried out to develop a tailored lexicon for deep-fried battered and breaded shrimp. Principal component analysis highlights that large breadcrumb sizes correlate with crispness, hardness, particle size, surface color, color uniformity, surface irregularity, total porosity, maximum force, area, drop in force, number of sound peaks, and sound pressure level. Agglomerative hierarchical clustering was used to confirm clustering of samples according to breadcrumb size. Multiple factor analysis confirmed overall correlation between sensory measurements and instrumental measurements (RV = 0.810). Partial least squares regression was used to develop a predictive model for crispness from instrumental measurements (R^2 = .854). The use of texture analysis and Acoustics provide information of the structures strength and deformation behavior, while X-ray microCT provides a high resolution and noninvasive method that acquires information on the internal morphology. These instrumental methods collectively demonstrate the relationship between microstructure to sensory. This study investigates how a change in the microstructure of deep-fried battered and breaded coatings affect crispness perception. These changes were investigated analytically and by using a sensory panel, this is important from a manufacturing perspective in order to understand what the major contributors are to a crisp texture. The key highlights of this study include both instrumental measurements and sensory measurements can be used to measure crispness as both types of testing are correlated. Changes in the size of breadcrumbs affect both instrumental measurements and sensory measurements. A predictive model can be re-simulated to allow prediction of crispness in deep-fried battered and breaded coatings.



1. INTRODUCTION

Deep-fat frying is a popular method of food preparation that is essentially a heat and mass transfer process. In deep-fried battered and breaded goods, crispness is a textural parameter that can be used to assess quality and freshness. The perception of crispness is dependent on rheological and mechanical characteristics as well as the sensations during eating (Roudaut, Dacremont, Pàmies, Colas, & Le Meste, 2002). Deep-fried battered and breaded products are favored by consumers due to their increased palatability provided by a crisp porous outer coating contrasting a tender and high-moisture core (Antonova, Mallikarjunan, & Duncan, 2003). As well as improving texture and taste, the use of deep-fried coatings improves appearance and shelf-life. The loss of crispness is typically due to adsorption of moisture from the atmosphere or water mass transfer from the internal components (Piazza, Gigli, & Ballabio, 2007). In the research described here, the deep-fried batter and breaded coating of a shrimp product has been studied to understand the major contributors to crispness perception.

1.1. Crispness perception

Microstructurally, the arrangement of the structure, composition of constituents, chemical bonds and imperfections will affect crispness perception (Chakra, Allaf, & Jemai, 1996). “Dry” crisp refers to cellular structures with air-filled cavities surrounded by brittle material that fractures upon being compressed beyond a threshold. The perception of crispness is due to fracturing of this brittle material (Duizer, 2001). Examples of dry crisp include roasted almonds or potato chips (Labuza et al., 2004; Tomasco, 2007). “Wet” crisp refers to cellular structures with turgor, caused by liquid within the cells pressing against the cell walls whilst being oppressed by elasticity and strength of the cell wall. The perception of wet crisp is due to the rupture of these cell walls, therefore increased turgidity increases crispness perception (Duizer, 2001). Examples of wet crisp include fruits or vegetables (Chauvin, Younce, Ross, & Swanson, 2008; Tomasco, 2007). Batter and breadcrumb coatings have properties of both wet and dry crisps and so can be referred to as “crusted” crisp (Tomasco, 2007). The maximum perception of crispness is during the first bite of the mastication process. This is due to the continuous breakdown of the food structure caused by incisors and the hydration of the sample from saliva, thus reducing crispness (Luyten, Plijter, & Van Vliet, 2004).

1.2. Instrumental crispness

Characterization of crispness using instrumental measurements have been previously investigated in hopes to try and predict its perception using a combination of morphological characteristics (Adedeji, Liu, & Ngadi, 2011), ultrasonic properties (Antonova et al., 2003), acoustics (Chakra et al., 1996) and force-deformation measurements (Salvador, Varela, Sanz, & Fiszman, 2009). The type of test or probe must be clearly established, as crispness varies from product to product. The textural term ‘crisp’ has a versatile definition and studies have been carried out on biscuits (Arimi, Duggan, O’sullivan, Lyng, & O’riordan, 2010), nuts (Saklar, Ungan, & Katnas, 1999), breads (Primo-Martin et al., 2006), and potato chips (Bouaziz et al., 2016) all of which are low-moisture crisp products. Studies on instrumental crispness of deep-fried crusted crisp products with a high-moisture core are limited.

1.3. Sensory crispness

In food texture studies, sensory assessment with a trained panel can be used to validate instrumental measurements (Fillion & Kilcast, 2002). The use of descriptive profiling is recognized as an efficient tool for characterizing crispness of fried products (Antonova, Mallikarjunan, & Duncan, 2004; Du Pont, Kirby, & Smith, 1992; Miele, Di Monaco, Formisano, Masi, & Cavella, 2018; Torrico et al., 2019). Crispness of deep-fried coatings is a versatile textural characteristic that will vary with batter formulation, breadcrumb formulation, frying time and frying temperature. Previous studies have shown that varying breadcrumb size affects the physical and mechanical properties of deep-fried battered and breaded coatings (Maskat & Kerr, 2002). The optimum time for assessment of crispness can be considered to be during the first bite, this is when surface rupture occurs and moisture has not yet migrated towards the crust (Luyten et al., 2004).

Although instrumental measurements have shown differences in structural parameters between coatings with variable breadcrumb size, sensory assessment is required to identify and distinguish any mouthfeel differences in crispness perception. Studies on high-moisture crisp products are limited, therefore this study aims to investigate (a) whether a panel is able to visually differentiate between crisp samples, (b) whether a panel is able to identify and describe differences in crispness between samples, (c) investigate any correlations between instrumental and sensory parameters, and (d) develop a predictive model for crispness. By correlating instrumental measurements to sensory data, this will provide useful information for food manufacturers to develop products with a desired level of crispness.

Go to:4, the first two dimensions explain a total variance of 88.51%. Each sample is represented by a central point, two partial points are then projected away from the central point. Each projected end representing either sensory measurements or instrumental measurements. If the two projected points are in close proximity to one another, this indicates agreement between sensory and instrumental measurements. Alternatively, if the two projected points are a part, this indicates discordance (Pagés & Husson, 2005). Figure
Figure4
4 shows that sample 355 μm to have the greatest agreement whilst sample 4.0 mm has the greatest discordance between it’s sensory and instrumental data. In general, as breadcrumb size decreases, agreement between sensory and instrumental increases. This can be explained as coatings with large breadcrumbs are amorphous in size, shape and therefore surface coverage. Subsequently, this will affect its mechanical and physical properties upon frying as well as sensory perception. Therefore, higher variability can be expected from instrumental and sensory measurements. This is further supported by Figure
Figure4,
4, as the position of the instrumental point of sample 4.0 mm is the furthest point from all others, suggesting that the instrumental measurements for sample 4.0 mm are more different than the other samples.