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Integration of fuzzy logic and computer vision in intelligent quality control of celiac-friendly products

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Abstract

Automation in food industry demands intelligent and feasible techniques to replace the human brain with machine intelligence. Quality control examines product attributes which cannot be quantified exactly and thus the relationship amongst the attributes parameters is unclear. The visual properties of the product can be more accurately and quickly examined by machine. Hence, in the present paper, a sensory evaluation was carried out on one of the main quality attributes as taste and was combined with two others as appearance and texture acquired by computer vision to determine the acceptable level of ingredients of a gluten-free cake (GFC). Analysis of samples using the aforementioned method indicated that acceptable levels of 50% purslane flour (PF) and 1% quince seed gum (QSG). Sensory evaluation indicated that the quality attributes can be ranked in a descending order as texture, taste and color. Employment of fuzzy logic and image processing was promising to indicate the optimum formulation of compounds as the top rank was found to be the third sample.

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Keywords: Image analysis; sensory evaluation; fuzzy logic; gluten-free cake; sensory evaluation.

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1. Introduction

Celiac disease is a genetically based autoimmune disorder affecting the gastrointestinal system and characterized life-long intolerance to the ingestion of gluten, which is prevalent in 0.71% (1 in 141) of adolescents and adults in the European country (Rubio-Tapia et al, 2012) Currently, the only effective and existing treatment for the disease is a life –long elimination of gluten – containing foods from the diet.

Some food additives such as gums have been widely used in the gluten- free food formulations to overcome these problem (Comes et al, 2007). The quince seed has a gum that was added to gluten – free cake formulation containing rice flour, purslane flour and another material. The physicochemical, sensory and transport properties of foods are largely dependent on crumb structure. Crumb structure affects appearance of crumb volume, color and texture of bakery product (Zghal Scanlon et al, 2002). Among the different classes of physical properties of bakery products, color is considered the most important visual attribute in the perception of product quality.

In recently year, automatic inspection in the based on machine vision technology has successfully been used for sensory evaluation of food and agriculture (Brosnan et al, 2004). Chandraratne and coauthors techniques used machine vision as well in the category of meat (Chandrarantne et al, 2007). Also Cubero the advantage of using machine vision techniques in automated inspection and reported quality evaluation of fruit and vegetables (Cubero et al, 2011). In another study Gonzales –Barron showed image processing and machine vision technique can as well be used to evaluate the characteristics of the bread crumb structure (Gonzales and et al, 2008).

Computer vision provides non-destructive method to objectively measure color patterns in non- uniformly colored surface, also determine other physical features such as morphological elements, image texture and defects. it is possible to extract visual features, such as texture, size, shape, and color being relevant for analysing a certain quality descriptor (Mendoza and Aguilera, 2004; Brosnan and Sun, 2003).

Traditional methods in determining the sensory evaluation food quality are used but these methods are time-consuming and costly to develop. These factors cause motivate for develop alternative methods in less time and with greater accuracy that evaluate the product specification. Image processing systems play a more and more important role in the food quality evaluation by maintaining accuracy and consistency while eliminating the subjectivity of manual inspection. The development of an image analysis system for determining the visual quality attributes of a cake is complicated by the vague linguistic descriptors often used by experts responsible for evaluating the product. One way of dealing with the discrepancy between the crisp numeric data output from image analysis and the more indefinite linguistic information from these experts describing a visual impression is to implement a fuzzy logic system. Fuzzy approaches have been successfully applied in many experiments that involved fuzzy data. Fuzzy logic is a very good candidate to replace the human perception in quality attributes measurements. Hence, in the present study, it was tried to proposed an affordable approach to further reduce the human intervention in the quality control of food products. In other words, the acceptable levels of ingredients were examined and evaluated for the optimum quality attributes.

2. Material and Methods:

2.1. Ingredients and preparation

Rice flour having 7.4 %, moisture, 10.48% protein, 1.01% ash, 0.82% fat, from the Dr. Oetker company in Izmir. Sugar (sucrose), salt and baking powder (Katsan, Qualette, Istanbul, Turkey). The entire egg from local market. Quince from local market and flour of purslane seed consumed from Iran-Bazr. The quince seed gum was extracted and purified according to the procedure described by Jouki et al, (2014). Preparation of the free gluten cake and baking according to the procedure described by Turabi et al, (2008) (See Fig.1).

2.4. Image analysis

The evaluation of crumb grain and crumb color of cake was performed using an image analysis system consisted of a canon digital camera (model SX60 HS, Japan) and a personal computer with a Pentium(R) Dual-core Processor

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