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Extended Abstract

The Effect of Xanthan, Guar and Transglutaminase on the Physicochemical and Textural Properties of Gluten-free Doughnut

Arezo Fazeli[1], Mostafa Mazaheri Tehrani[2*], Mahdi Karimi[3], Alireza Sadeghian[4], Arash Koochaki[2]

1- PhD. Student, Department of Food Science and Technology, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran
2- Professor, Department of Food Science and Technology, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashahd, Iran
*Corresponding author (mmtehrani@um.ac.ir)
3- Associate Professor, Agricultural Engineering Research Department, Khorasan Razavi Agricultural and Natural Resource Research Education Center, Agricultural Research, Education and Extension Organization (AEERO), Mashhad, Iran
4- Assistant Professor, Department of Food Processing, Research Institute of Food Science and Technology, Mashhad, Iran

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Abstract
The main objective of the current study was to optimize gluten free doughnuts formula for which the effect of xanthan, guar and Transglutaminase (TGase) enzyme were investigated. Xanthan, Guar and TGase were added from 0 to 2% of flour basis to the basic formula. Treatments were designed based on the mixture design of the Minitab software. The optimum conditions were selected based on the oil absorption, hardness, color, porosity and specific volume. The results showed that the high oil absorption occurred at the high level of TGase in absence of gums and the minimum oil absorption happened at the triple point. TGase caused cross linkage between rice flour protein, potato flour protein, and soy protein concentrate, which led to making protein network, xanthan gum, creating viscoelastic properties and guar gum, generating inter-surface properties, finally resulting in the increase of porosity and specific volume of doughnuts respectively. The interaction between the components showed that increasing the amount of guar gum improved the lightness of doughnuts. Texture parameters showed that samples with just gums without TGase showed the highest hardness. The synergistic effects of these gums increased viscosity. Hardness was decreased by protein network induced by TGase. The results of this study showed that the formula containing all three components could simulate the protein network in the gluten-free doughnut. The optimum point was 0.98% of xanthan, 0.44% of guar and 0.58% TGase which showed the best responds.

Keywords: Celiac, Doughnut, Gluten-free, Hydrocolloids, Transglutaminase

Introductıon
Celiac disease is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals Gluten is the protein component in wheat, rye and barley. At present, the only available treatment for celiac patients is a strict gluten-free diet. Bakery

products are the main source of gluten. Doughnut as fried snack is a favorite bakery product which sales annually about 3-4 billion US dollar just in the United State (Tan & Mittal, 2006) The most important problems involved with gluten free products are keeping sponginess and cohesiveness of gluten free product’s texture, reducing hardness and delaying staling over the time (Peshin, 2001).

Gums are effective ingredients that can retain moisture and gas in dough texture, improve products texture and reduce staling rate (Bárcenas, Benedito, & Rosell, 2004; Guarda, Rosell, Benedito, & Galotto, 2004). In addition to gums, enzymes used in bakery products because they can reduce crumb hardness, retard staling and improve dough strength (Gray & Bemiller, 2003).

Sumnu, Koksel, Sahin, Basman, & Meda (2010) determined the effects of different concentrations of xanthan and guar gums and their blends on staling gluten-free rice cakes baked in microwave-infrared combination oven. They found xanthan-guar gum blend decreasing hardness, losing weight, retrograding enthalpy and changing in setback viscosity values of cakes during storage for both types of ovens as compared to control formulation. Also confocal laser scanning microscopy and sodium dodecyl sulfate-polyacrylamide gel electrophoresis analysis confirmed that the TGase promoted the formation of protein complexes.

Material and methods

Doughnut dough preparation

Ingredients include rice flour, potato flour, egg and sugar bought from local market. Dry active yeast provided by (Iran Mellas, Iran). Xanthan and guar gums plus TGase were bought from (Eliot, USA Modernist Pantry). Soy Protein Concentrate (SPC) provided by (Shandong Sanwei, China) and Shortening by (Crisco, USA).

Professional Kitchen aid mixture (Artisan, USA) used to prepare dough. At first the egg was blended for 3 min at high speed, then shortening was added and mixed for 1 more min. At next step, the dry ingredients were added to the egg and shortening mixture and they were mixed for 5-8 min. Prefermentation was done at 38 °C and relative humidity 85% for 15 min. After that the dough sheet was cut with 1 cm thickness by doughnut standard cutter. Final fermentation was done for 45 min at the same condition as prefermentation. After final proofing the dough was deep fried at 170 °C oil temperature.

Oil uptake percentage was calculate by (Alipore, Kashani Nezhad, Maghsudlo, & Jafari, 2009).

Porosity was calculated by image processing method (Haralick & Shanmugam, 1973). Specific volume, calculated by AACC (2000) 10-05 method. Crust lab color was determined by Sun (2011) image processing technique. Texture hardness was calculate by using texture profile analysis method defined by Karim, Norziah, & Seow (2000).Static analysis was done by Minitab V16 as simplex centroid mixture design.

Results and discussion

Most of oil adsorption observed at highest level of TGase and in the absence of gums. Gums had high influence to reduce oil uptake by their water retention properties. Sakhale, Badgujar, Pawar, & Sananse (2011) concluded as much as moisture loss increases, oil adsorption also increase. Interaction between xanthan and guar had the best effect on reducing oil adsorption.

TGase had highest independent effect on increasing porosity. Among different interactions triple effect of variable increased porosity to highest level. Incorporation of gums increased the thickness of air bubbles. The air bubbles with thick walls resist against expansion during the baking process and do not rupture easily. This will result in an increase of gas cells numbers and their uniform distribution in the product which in turn, increases porosity of final product (Ziobro, Korus, Witczak, & Juszczak, 2012). İn present of TGase greater cross-linkages between protein sources (soy protein concentrates, lysine's of rice flour and potato flour) formed a wider protein network. As a result, the CO_2 gas bubbles that expanded during frying were trapped in protein network quickly which made the final texture became more porous.

Guar had highest independent effect on increasing specific volume. Among different interactions triple effect of variable increased specific volume to highest level. Guar powder had protein impurities which caused the stability of air bubbles in a dough emulsion by creating electrostatic interactions. Fazeli (2012) concluded protein impurities is responsible of surface and interfacial tensions of emulsions made of cress seed gums. In addition, xanthan could maintain CO_2 and increase specific volume due its ability to produce viscoelastic properties similar to gluten.

Guar had highest independent effect on increasing lightness and yellowish while TGase increased the redness of doughnuts crust. Among different interactions Xanthan-TGase, Guar-Xanthan and triple effect of variables increased the lightness, redness and yellowish, respectively.

Xanthan independent effect and Xanthan-Guar interaction increased doughnut hardness to higher levels. In the presence of gums, the air bubbles were stabilized and their cell wall was strengthened, so the resistance of these samples containing both gum increased against the pressure pushed by the device and the hardness of the texture also increased. On the other hand, it should be considered that these two gums have a synergistic effect on viscosity, which itself leaded to increase hardness (Kokelaar, 1994).

Conclusion

Xanthan gum produced viscoelastic properties, guar gum reduced surface tension and their interaction increased viscosity, as well as the expansion of the protein network caused the creation of cross-linkage. TGase enzyme rearranged the protein network. These alterations caused high quality product. Based on the results obtained, independent effect of variables could not cause a high quality product. Interactions of Xanthan-Guar-TGase led to the production of an acceptable gluten free doughnut. Based on responses optimization, formula with 0.98% xanthan gum, 0.44% guar and 0.58% TGase enzyme was known as the best combination.

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