Development and Characterization of Rice Based Gluten Free Bread

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by

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ABSTRACT

Worldwide consumption of wheat bread is due to its quality, convenience, palatability, longer shelf life. It is evidenced that gluten is the most paramount factor affecting bread baking properties. However, in certain genetically susceptible individuals, an autoimmune disorder such as celiac disease (CD), triggered by the ingestion of gluten-containing produces can occur. This necessitates the development of suitable gluten free product. The present research was aimed to develop a process technology for preparation of gluten-free (GF) rice based bread. The influence of rice flour and corn flour on the rheological and textural properties of gluten free rice based bread batter was studied. The substitution with pre-gelatinized rice flour (25% to 35%) and xanthan gum (1%) resulted in a significant increase ($p < 0.05$) in the elastic ($1.0\text{-}4.5\times10^5$ Pa) and viscous moduli ($4.5\text{-}7.5\times10^4$ Pa) and diminished deformation compliance values ($2.3\text{-}4.0\times10^{-5}$ Pa^{-1}). The ingredient composition of GF bread was optimized using response surface methodology. The numerical optimization for the formulation of GF bread suggested a proportion of xanthan gum : rice flour : corn starch having a desirability index value of 0.82. Regression models for three different responses viz. specific volume, crumb firmness and overall acceptability of the bread described well the variability of the experimental data (respective R^2 values are 0.94, 0.89 and 0.88). Upto a certain limit of xanthan gum addition, the specific volume of the bread increased and its crumb firmness decreased. The specific volume and crumb firmness were not significantly affected by the collective effect between rice flour and xanthan gum at fixed corn starch level. Microwave (MW) heating was found to be the dominant mechanism in infrared (IR)-MW combination baking in terms of affecting weight loss and texture development. This combination baking provided specific volume and crust color similar to the conventionally baked bread; however, the weight loss and firmness were higher as compared to conventionally baked ones. Robust heat and mass transfer during baking was studied using multiphysics tool COMSOL. The model is calibrated and validated. The parameters (k_{evp} and h_{bot}) were estimated by fitting the simulated temperature profile to the data available for position A (T_{set} = 160 °C). The estimation results, presented as nominal value ± confidence interval of the parameter, are: $k_{evp} = (11.4\pm0.2)\times10^{-5}$ and $h_{bot} = 360.7\pm12.8$. The developed GF bread formulation is xanthan gum : rice flour : corn starch = 0.94 : 24.91 : 25.11; its manufacturing process technology includes two step mixing at 90 rpm for 2 min and 180 rpm for 6 min, baking at 210 ºC for 40 min in hot air circulatory baking oven followed by cooling to room temperature (25 ºC). The developed GF bread has good nutritional and sensory characteristics which are comparable to the standard white bread. The shelf life of the developed GF bread was determined and its spoilage kinetics was established using electronic nose. The developed GF bread was found to be stable up to 6 days under ambient (25 ºC and 60% relative humidity) condition. During this period, there was no appreciable change in its sensory and microbiological quality. A rapid FT-NIR method was also developed to determine the moisture content in GF bread.

Keywords: Celiac disease, Gluten free bread, Drying, Electronic nose, FT-NIR, Response surface methodology, Microstructure, Rheology, Rice flour