ABSTRACT

Bread, an ideal functional cereal product has been consumed widely all over the world despite a wide variation in types and forms based on cultural habits. However, consumption of a particular product on a regular basis evidenced some detrimental effects on health such as lysine deficiency and coeliac disease caused due to the frequent consumption of wheat. Thus, the demand for commercially marketed nutraceutical items has generated a need for healthy functional ingredients which can be shelf-stable as well as simple to use in formulations. In this aspect, germinated (sprouted) grain products are the most recent advances in the cereal world owing to several nutritional, functional and sensorial benefits. In this study, the sprouted wheat flour was proved to have higher nutritive values, antioxidative properties and digestibility. In contrast, the sprouted wheat flour depicted poor dough rheology and water hydration properties resulting in inferior baking quality. So, sprouted wheat flour (SWF) should be fortified with nutritionally rich cereal grains like rye, oat, barley, and almond to develop a functional multigrain bread. The influence of addition of rye (10-20%), oat (3-5%), barley (10-12%), and almond (5%) with SWF (65-70%) on dough gelatinization temperature, water absorption index (WAI) and loaf volume was studied. The substitution of rye, oat, and barley with SWF significantly ($p<0.05$) increased the gelatinization temperature from 61.72-69.14°C, loaf volume from 27.44-61.72% and WAI from 1.85-2.58 respectively. The ingredients composition was optimized using response surface methodology (RSM) and the numerical optimization revealed that dough containing 65% SWF, 20% rye, 10% barley and 5% oats exhibited optimal gelatinization temperature, loaf volume and WAI. The optimized dough mixed with 5% almond flour was baked in a conventional baking oven. The effects of baking temperature (180-200°C) and time (20-30 min) on bread quality parameters like crumb hardness, total colour change in crumb and crust and specific loaf volume were assessed and optimized using CCRD-RSM and PCA-RSM hybrid technologies. Bread baked at 190°C for 25 min explored the optimal condition of crumb hardness (3.622 N), total colour change in crumb (22.37) and crust (14.42) and specific loaf volume (2.41 cc/g). Robust heat and mass transfer during baking was studied using COMSOL Multiphysics by fixing the boundary conditions as T= 190°C and t= 25 min. The models were calibrated and validated. The strong positive correlation (r= 0.99) between experimented and simulated temperature profile and water distribution profile indicated the baking performance of the oven. The developed multigrain bread has enhanced proximate values, mineral composition and antioxidant properties with rich in phenolics like ferulic acid, p-coumaric acid, vanillic acid, caffeic acid and ethyl gallate. The developed bread was stored at four different temperature viz., 5, 25, 35, and 45°C for six days to assess the shelf-life and microbial spoilage. The bread was found to be stable up to six days at ambient condition (25°C and 75% RH). During this period, the bread quality parameters like bread texture, colour, water activity and microbial load were within safe limits for consumption.

Keywords: SWF, Multigrain bread, Baking, Rheology, CCRD, RSM, PCA, Shelf-life