

Full length Research Paper

Optimization effect of germination on functional properties of wheat flour by response surface methodology

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The present study focused on optimization of functional properties of wheat flour prepared from germinated wheat seed. For optimization of germination conditions (time and temperature) study was designed by using the Response Surface Methodology (RSM), with a central composite rotatable design (CCRD). The wheat seeds were germinated at 30-37 °C for 48-72 hours. Germinated wheat seed flour was evaluated for functional properties. The results shows that bulk densities (packed and lose) of germinated wheat flours were lower. Germination process increased water absorption capacity of wheat flour at ambient conditions but decreased in oil absorption capacity .The increase in foaming capacities and reduction in foam stability of all samples was recorded. Thus, the study indicated that germination improved the functional properties wheat flour. Germinated wheat flour can be successfully used for preparation weaning foods for proteins deficient children.

Keywords: Germination, wheat, RSM, optimization, functional properties.

INTRODUCTION

The wheat (*Triticum* spp.) is cultivated worldwide. Globally, wheat is the most-produced food among the cereal crops after rice. Wheat grain is a staple food used to make flour for leavened, flat and steamed breads; cookies, cakes, breakfast cereal, pasta, noodles; weaning food and for fermentation to make beer, alcohol, vodka or even bio fuel. Among the various seeds of cereals, the wheat grains provide more food to over one thousand million human beings of this earth than any other plant or animal products (USDA, 1961). Wheat is the most plenteous food crop, based on the area planted and it in fact competes with rice in the amount harvested. Its unique taste and the light leavened texture of its products stand it at the top of the list of food liked by the people living in every part of the world. These include bread, cakes, cookies, biscuits, pasta, breakfast cereals etc. All of these products are possible due to presence of

a unique elastic protein complex known as gluten complex, forming a visco-elastic dough that is preferred for leavened and un-leavened products (Cornell, 2003).

Germination has often been proposed as a simple processing method by which the nutrient composition and certain functional properties of seeds might be improved (Giarni, 1993) and by which the quality of a cereal can be improved for both digestibility and physiological function. During germination, enzymatic activity and bioactive compounds increased within the seed. Germination is induced by rehydration of the seed, which increases both respiration and metabolic activity that allow the mobilization of primary and secondary metabolites. (Bohoua, et al., 2007) and improves the nutritional and functional qualities of sorghum by changing chemical compositions and eliminating antinutritional factors. (Abbas et al., 2008). The functional properties, which reflect mainly the quantity and the quality of the protein and the fiber contents, are required for selecting suitable utilization in food preparation and these properties varied clearly among different sources. (Xu and Diosady 1994).The reduction in the bulk density of the germinated

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flours would be an added advantage in the preparation of supplementary foods (Akubor and Obiegbuna, 1999). Low bulk density food is desired where packaging is a serious problem (Ikujenlola, 2008). Water absorption capacity is important in the development of ready to-eat-food cereal grains, since a high water absorption capacity may assure product cohesiveness (Houssou and Ayernor, 2002). Oil absorption capacity is a critical assessment of flavour retention and increases the palatability of foods (Kinsella, 1976). Swelling capacity is the volume of expansion of molecule in response to water uptake which it possessed until a colloidal suspension is achieved or until further expansion and uptake is prevented by intermolecular forces in the swelled particle (Houssou and Ayernor, 2002). Response surface methodology (RSM) is an effective statistical technique for optimizing complex processes. The main advantage of RSM is the reduced number of experimental trials needed to evaluate multiple parameters and their interactions with less laborious and time-consuming (Irakoze *et al.*, 2010). The objective of this study was to prepare and evaluate the functional properties of wheat flour assess the changes in functional properties brought by germination.

MATERIALS AND METHODS

Preparation of wheat flour

Wheat flour (WF) samples prepared by taking 300 grams of seed and was sterilized by soaking in ethanol 2% for 1 min. The seeds were then soaked in tap water for 12 h at room temperature. The soaked seeds were germinated in a plastic tray lined with wet paper towels. Two layers of wet paper towels were used to cover the seeds to prevent rapid moisture loss. They were germinated in the seed germinator at 33.5 ± 2 °C for 60 h. The sprouts were washed and dried at 60°C for 12 h in an electric oven (Contherm, Quanttherm 200 L, Contherm Scientific, Lower Hutt, New Zealand). The dried sprouts were ground in a hammer mill (Culatti, Model: JKA Werk, Type: DCFH, Germany) and sieved with a 60 mesh screen (Model BS 410, Endeco London, England). The flour was kept, in triplicates, into polyethylene bags and packed in a glass container and stored in a refrigerator at 4°C until nutritional analysis (Mubarak, 2005).

Functional Properties

The pH was measured by making a 10% (w/v) flour suspension of each sample in distilled water (AOAC, 2005). Each sample was then mixed thoroughly in a plastic beaker, and the pH recorded with an electronic pH meter (Model PHN-850, Villeur-Banne, France). The bulk

density (BD) (packed and loosed densities) was determined according to the method described by Okezi and Bello (1988). The water and oil absorption capacities were determined by the method of Adebowal and Lawal (2004). Two grams flour sample was mixed with 20 ml distilled water or refined soybean oil (S.G. 0.9084) and allowed to stand at ambient temperature (32°C) for 30 min, then centrifuged for 30 min at 2000 x g. Water and oil absorption capacity was expressed as percent water or oil bound per gram flour. The foam capacity (FC) was determined as described by Narayana and Narsinga (1984). Swelling power was determined through the method described by Tester and Morrison (1990) Water solubility was measured according to the method of Anderson (Anderson *et al.*, 1996).

Experimental design

Variation effects in germination time and temperature were analyzed using the response surface methodology (RSM), with a 2 factorial central composite rotational design. The independent variables studied were germination time (48-72h) and germination temperature (30- 37°C). Symbols and coded factor levels for these variables are given below:

Statistical analysis

Statistics 5.0 (Stat soft, USA) was used to determine the effects of the independent variables, to calculate regression coefficients carry out analysis of variance (ANOVA) and build the response surface, at a 5% significance level. The following second order polynomial model was fitted to the data:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{12} X_1 X_2 \quad (1)$$

Where Y is the response variable, X₁ and X₂, are the coded process variables and $\beta_0, \beta_1, \beta_2, \beta_{11}, \beta_{22}, \beta_{12}$ are the regression coefficients. A stepwise methodology was followed to determine the significant terms in Equation 1. The experimental data were fitted to the second order polynomial model instead of second order polynomial was fitted to the data. Regression coefficients were obtained from the second order polynomial model.

RESULTS AND DISCUSSION

The pH values obtained from germinated wheat seeds flour varied from 4.8 to 5.3. The regression model for this parameter was significantly different ($p < 0.05$). The 2nd order adjusted model for pH is presented in Eq. (2) and the response surface in (Fig.1). The pH values of the flours in water suspension are important since some functional properties such as solubility and emulsion properties are highly affected by pH changes (McWatters,

Table 1. Optimized values for independent variables and response for wheat flour

S. #	Responses	Independent variables (Optimum Values)				Optimum Value for Response
		Temperature (°C) X ₁		Time (h) X ₂		
		Uncoded	Coded	Uncoded	Coded	
1	pH	28.76	-1	43.02	-1	5.25
2	P.Bulk Density (g/cm ³)	28.55	-1	43.02	-1	0.5811
3	L. Bulk Density (g/cm ³)	38.44	1	43.02	-1	0.6403
4	Water absorbs. Cap.(ml/g)	34.13	1	54.48	1	2.39
5	Oil absorbs. Capac.(ml/g)	32.62	1	59.44	1	1.78
6	Foam Capacity (%)	38.44	1	43.02	-1	52.41
7	Swelling Capacity (%)	33.60	1	58.91	1	6.22
8	Solubility (%)	33.51	1	59.98	1	15.42

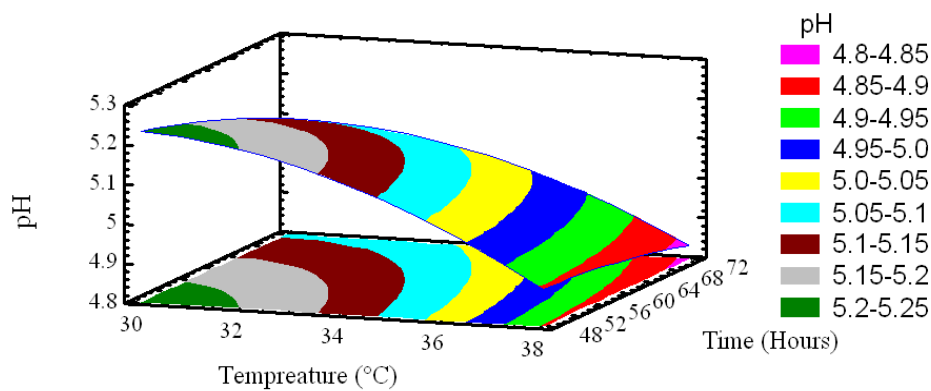


Figure 1. Response surface plot for effect of germ on BD wheat flour

1985). Optimum values for pH and independent variables (temperature and time) are 5.25, 28.76°C and 43.02h results showed in (Table 1).

$$pH = 2.2697 + 0.225709 * X_1 + 0.00848521 * X_2 - 0.00423476 * X_1^2 + 0.000416667 * X_1 * X_2 - 0.0000824624 * X_2^2 \quad (2)$$

Results of bulk density of germinated wheat flour varies from 0.49 to 0.57 (g/cm³) for packed bulk density and for lose bulk density varied from 0.60 to 0.65 (g/cm³). The 2nd order adjusted model for pH is presented in Eq. (3 & 4) and the response surface in (Fig. 2 & 3). Bulk density is an important functional property of flour and it is significant for the preparation of weaning food. Germination has been reported to be a useful method for the preparation of low bulk weaning foods (Desikachar, 1980). Optimum values for pack and lose density and independent variables (temperature and time) are 0.58 g/cm³, 28.55°C, 43.02 h, 0.64 g/cm³, 38.44°C and 43.02h respectively results showed in (Table 9).

$$Pack\ BD = 2.20101 + 0.0700575 * X_1 + 0.0158363 * X_2 - 0.000658176 * X_1^2 + 0.000392857 * X_1 * X_2 - 0.0000230032 * X_2^2 \quad (3)$$

$$Lose\ BD = 0.193062 + 0.00545287 * X_1 + 0.0103567 * X_2 + 0.000153064 * X_1^2 - 0.000244048 * X_1 * X_2 - 0.0000164993 * X_2^2 \quad (4)$$

Values for water absorption capacities varied from 2.0 to 2.4 ml/g and oil absorption capacity (1.74 to 1.83 ml/g) for germinated wheat seed flour. The 2nd order adjusted model for water and oil absorption capacities are presented in Eq. (54 & 55) and the response surface in (Fig. 4 & 5). Water absorption capacity is more than oil absorption capacity. This factor is important for those seed flour which used for preparation of soup condiments. The results were agreed with some past findings like, (Giarni and Wachuku 1997; Giarni et al, 1994; Giarni, 1993). Optimum values for water and oil absorbance capacities and independent variables (temperature and time) are 2.39 ml/g, 34.13°C, 54.48 h and 1.78 ml/g, 32.64°C and 59.44h respectively results showed in (Table 1).

$$Water\ AC = 3.46825 + 0.0217679 * X_1 + 0.0789599 * X_2 - 0.00352057 * X_1^2 + 0.000416667 * X_1 * X_2 - 0.000855032 * X_2^2 \quad (5)$$

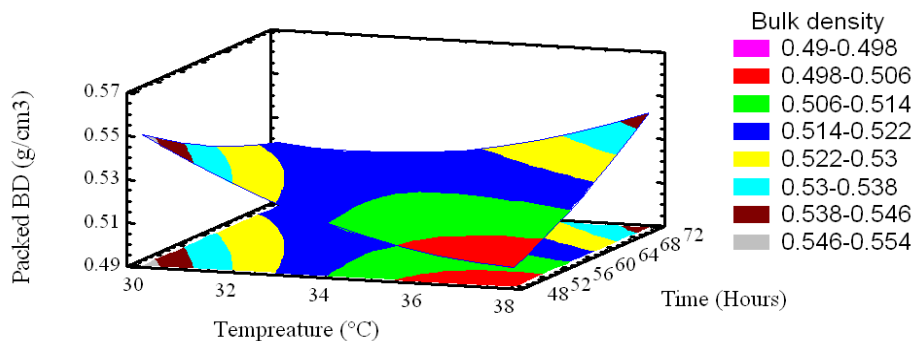


Figure 2. Response surface plot for effect of germ on BD wheat flour

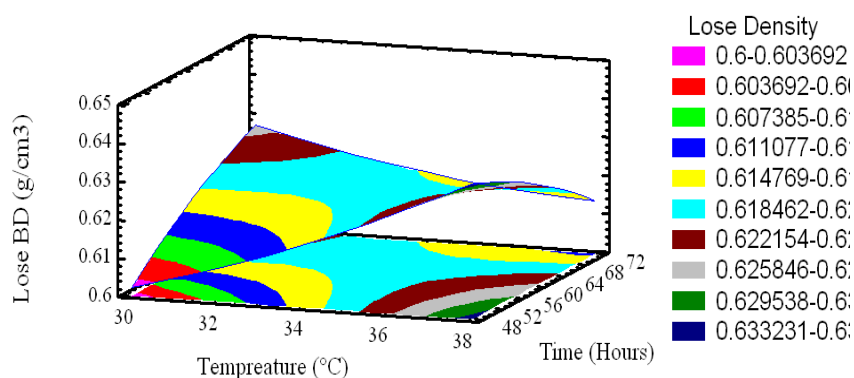


Figure 3. Response surface plot for effect of germ on BD wheat flour

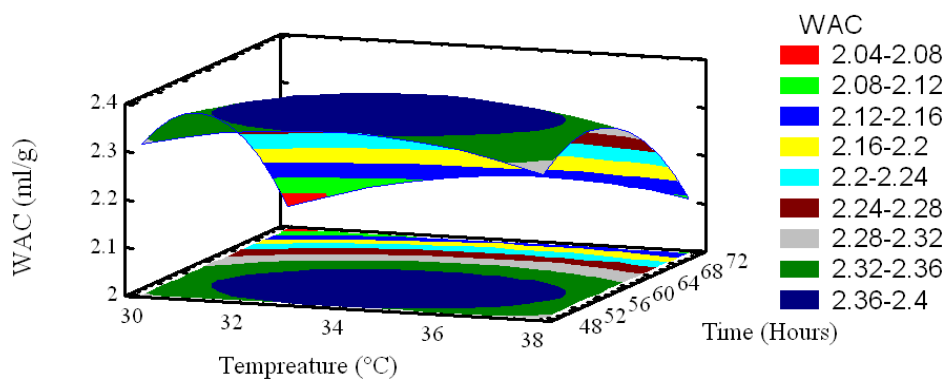


Figure 4. Response surface plot for effect germi on WAC of wheat flour

$$\text{Oil AC} = 0.142622 + 0.0772104 \cdot X_1 + 0.0223362 \cdot X_2 - 0.00102042 \cdot X_1^2 - 0.000178571 \cdot X_1 \cdot X_2 - 0.000138888 \cdot X_2^2 \quad (6)$$

Germination increased foam capacity. Values obtained from germinated wheat seeds flour varied from 52.00 % to 52.40 %. The regression model for this parameter was

statistically significant ($p < 0.05$). The 2nd order adjusted model for foam capacity is presented in Eq. (7) and the response surface in (Fig.6). The formation of stable foam is essential in the preparation of several traditional food products in Nigeria (Ngoddy, 1986; McWatters, 1985). Foam volume increase was influenced by pH, like

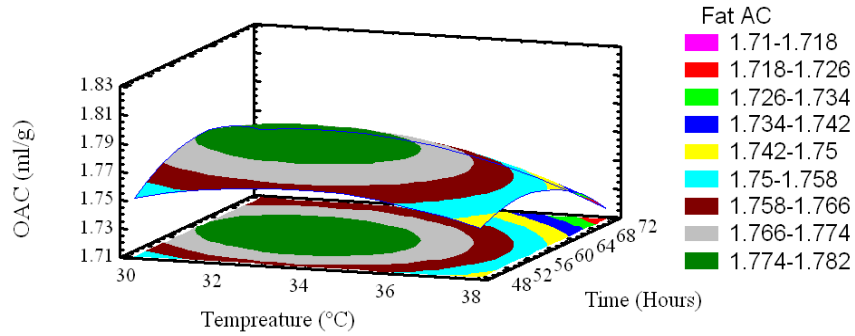


Figure 5. Response surface plot for effect germi on OAC wheat flour

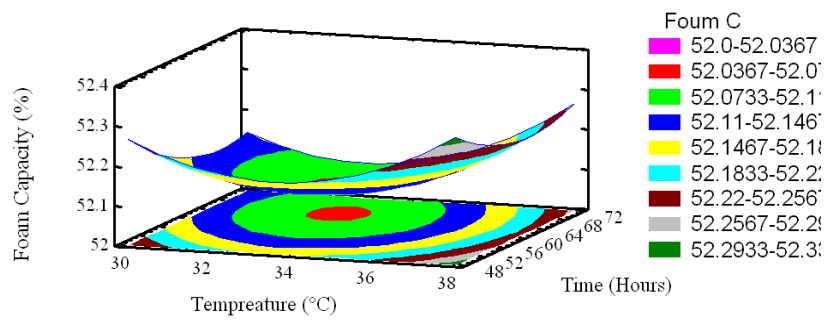


Figure 6. Response surface plot for effect of germi on foam C. of wheat flour

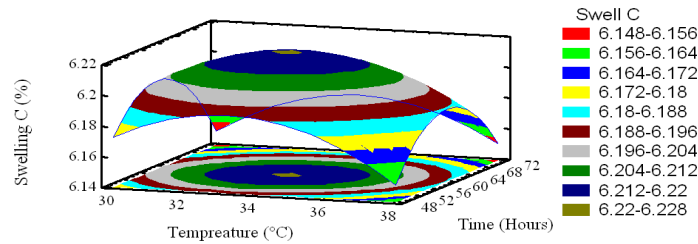


Figure 7. Response surface plot for effect of germi on swelling C wheat flour

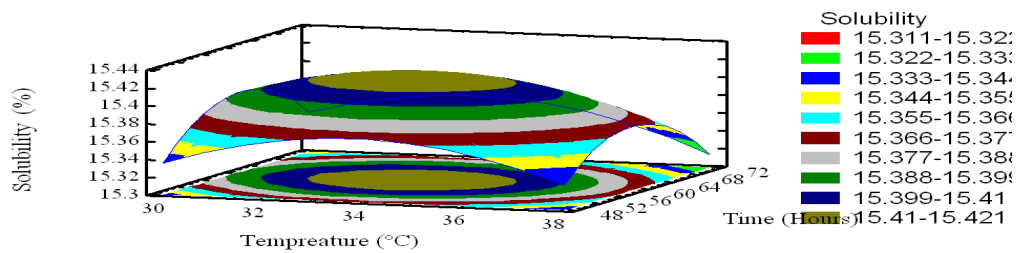


Fig. 8: Response Surface plot effect of germi. on solubility of wheat flour

Figure 8. Response surface plot for effect of germi on solubility of wheat flour

nitrogen solubility. Optimum values for foam capacity and independent variables (temperature and time) are 52.41 %, 38.44°C and 43.02h results showed in (Table 1).

$$\text{Foam Capacity} = 62.0483 + 0.0482208 * X_1 - 0.0615725 * X_2 + 0.00693891 * X_1^2 + 0.000357143 * X_1 * X_2 - 0.000381941 * X_2^2 \quad (7)$$

In this study germinated wheat flour had values for swelling power ranged 6.14 to 6.22 %. Therefore, the resulting swelling power indicated that the starch extracts obtained were highly restricted type. The regression model for this parameter was statistically significant ($p < 0.05$). The 2nd order adjusted model for swelling power is presented in Eq. (8) and the response surface in (Fig.7). With the increase in swelling power, starch solubility similarly increased. This is seen as mainly the result of granule swelling permitting the exudation of amylase (Dengate, 1984). Optimum values for swelling capacity and independent variables (temperature and time) are 7.22 %, 33.60°C and 58.91h results showed in (Table 9).

$$\text{Swelling Capacity} = 3.62316 + 0.109589 * X_1 - 0.0256561 * X_2 - 0.00173473 * X_1^2 + 0.000119048 * X_1 * X_2 - 0.000251735 * X_2^2 \quad (8)$$

Solubility was pH dependent with minimum and maximum solubility at pH 4.0 and pH 10.0, respectively, this finding suggests a promising applicability of flour. Values obtained from germinated wheat seeds flour varied from 15.30 to 15.44 %. The regression model for this parameter was statistically significant ($p < 0.05$). The 2nd order adjusted model for solubility is presented in Eq. (9) and the response surface in (Fig.8). Improvement in nitrogen solubility as a result of germination has been reported by (Singh, 1991) for soybean. Optimum values for solubility and independent variables (temperature and time) are 15.42 %, 33.51°C and 59.98h results showed in (Table 1).

$$\text{Solubility} = 11.1809 + 0.171314 * X_1 + 0.0456262 * X_2 - 0.00244903 * X_1^2 - 0.000119048 * X_1 * X_2 - 0.000344722 * X_2^2 \quad (9)$$

CONCLUSION

Using response surface the optimum set of operating variables obtained graphically, in order to achieve the desired levels for functional properties of germinated wheat seeds flour. Therefore, it was recommended that the germination effect wheat seed decrease when the temperature and time increase. It can be inferred that variables (time and temperature) individually had positive effect on functional properties of germinated wheat seed flour. The main effects of parameters are in following order: Main effect of time > temperature. All the derived mathematical models for the various responses were found to be significantly fit to predict the data.

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