Original Research Article

Optimization of colour parameters of different gluten-free pasta samples using response surface methodology

Abstract:

Colour plays important role in consumer's perception and acceptability of the food product. Therefore, Colour measurement and analysis is one of the most important quality attributes to optimize the quality and value of food. Different blends of gluten-free maize flour, finger millet (Ragi) flour and quinova flour were used as raw materials for the development of pasta. Hunter Lab Colorimeter was used for measuring the surface color of the uncooked pasta samples. High quality pasta (either fresh or dried) is normally yellow in colour and degree of yellowness can be calculated by using b* and L* values. Quality of pasta developed by different blend ratio of maize, ragi and quinova flours with different levels of CMC, Karaya Gum and dried at different drying temperature and air flow rate were evaluated in terms of L* values (lightness), b* values (yellowness) and Yellowness Index (YI). Results of colour analysis of gluten-free pasta samples indicated significant effect of flours on L*, b* and YI while drying air temperature have significant effect on b* values. Pasta samples prepared following optimized formulation 50:25:25 (Maize flour: Ragi, flour: Quinova flour) blend ratio, 5g CMC per 100g of blend ratio, 2.5g Karaya Gum per 100g of blend ratio, 60 ^{0}C drying air temperature and 0.78 m/sec. air flow rate provided optimum L*, b* and YI values with overall desirability 0.545.

Key words: Gluten, Colour, CMC, Karaya Gum, YI

1. Introduction

Millets and pseudocereals are largely used for cooking and consumption similar to milled rice. They can pulverized into flour and suji and used for roti and other foods similar to rice or wheat flour and semolina. Several R&D institutes, especially ICAR-IIMR, have been diversifying the value addition technologies such as puffing, baking, popping, flaking, cold and hot extrusion, expanded millets, instant/convenience foods, etc. (Dayakar, 2016). Through these technologies, there is a possibility to prepare millet and pseudocereal fortified products with enhanced taste and nutritional quality. Millet-based RTE foods—puffs, flakes, muesli, extruded snacks, cookies, murukus, etc.—and RTC foods—vermicelli, pasta, millet semolina (medium, fine, and coarse), instant mixes, etc.—were developed, including millet-plus-milk-based beverages (Krishnan, 2012).

Pasta is one such traditional cereal-based food product that is becoming increasingly popular worldwide because of its convenience, nutritional quality, and palatability. Owing to the increased market demand for pasta, the production has to be done without sacrificing the pasta's quality. Pasta is a staple food in many countries; however, it is still considered a snack food in

India. Conventionally, pasta products are prepared from durum wheat flour (Feillet and Dexter, 1996); however, trends towards the utilization of composite flour for pasta production are increasing gradually.

Colour plays important role in consumer's perception and acceptability of the food product. Therefore, colour measurement and analysis is one of the most important quality attributes to optimize the quality and value of food. High quality pasta (either fresh or dried) is normally yellow in colour and degree of yellowness can be calculated by using b* (Yelloness) and L* (Lightness) values. As far as pasta is concerned, it is the colorimetric coordinate b* and YI (Yellowness Index) that assumes the greatest importance, as it represents the colour yellow (Francis, F.J., 1995). The value of surface color of raw pasta was measured in triplicates using Hunter Lab Colorimeter. Colour readings were expressed by Hunter values for L*, a* and b*. L* values measure black to white (0e100), a* values measure redness when positive and b* values measure yellowness when positive (Clydesdale, F. M., 1978).

2. Materials and Methods

Design matrix table (5 x 5) developed by RSM CCRD Design Expert model 11.1.2.0 were used for preparation of 32 different runs.

For preparation of pasta samples with different blends maize flour percentage taken fixed 50g/100g for all samples and ragi flour varies from 10-30 g/100g while quinova flour adjusted according to ragi flour to make the blend 100g, varies from 20-40g/100g. CMC varies from 2-6 g/100g and karaya gum ranges from 1-3g/100g while salt content were taken fixed 1g/100g of the sample.

Pasta machine (Model-MAC7) (Fig. 1) fitted with adjustable die (tubular type) & one blade cutter were used to develop pasta samples of uniform length. Developed pasta samples were dried in convective tray dryer using drying air temperature (DAT) varies from 50-70^{0}C and air flow rate (DAV) varies from 05-1.5 m/sec.

Fig. 1: Pasta Machine

Fig. 2: Hunter Lab Colorimeter

The developed dried pasta samples were analyzed for L* (Lightness) and b*(Yellowness) using Hunter Lab Colorimeter (Fig. 2).

YI (Yellowness Index) indicates degree of yellowness can be calculated by using formula:

YI=142.86 b*/L* (Rhim et al. 1999).

Response surfaces for different blends were generated using the software.

3. Results and discussion:

The colour parameters were optimized using CCRD. Five factors five levels were studied to get the optimum values. The design sheet of different independent variables; blend ratio, CMC (CarboxyMethyle Cellulose), KG (Karaya Gum), DAT (Drying Air Temperature) and AFR (Air Flow Rate) was generated and the responses colour parameters L*, b* and YI (Yellowness Index) was analyzed on the basis of ANOVA and regression coefficients. The effect of different process variables was studied on different responses to obtain an optimum solution.

ANOVA

The results of ANOVA for the effect of process variables on all responses of colour parameters were analyzed. For all the responses the F value was greater than probability (p value) and was more than 0.05 for the models. Thus, the terms in the models had a significant effect on the responses. The lack of fit was insignificant for all the responses, indicating that the model fit the data well. The higher regression coefficient (R^2) values were 0.9472, 09729 and 09673 for L*, b* and YI respectively, suggesting a fair fit of the model. The lower CV values3.01%,2.14% and 4.49% for L*, b* and YI respectively indicated that the results were precise and reliable.

Effect of process parameters on L* (Lightness):

The regression equation describing the effect of the process variables on L* of pasta samples in terms of actual level of the variables are given as:

$$\text{Colour, } L^* = -112.47265 - 0.205621FMF - 9.74811CMC + 3.84379KG + 5.27997DAT + 31.64424DAV - 0.061000FMF * CMC - 0.026000FMF * KG + 0.004450FMF * DAT - 0.093000FMF * DAV + 0.827500CMC * KG + 0.104000CMC * DAT - 0.650000CMC * DAV - 0.020000KG * DAT - 3.24000KG * DAV - 0.195000DAT * DAV - 0.006064FMF^2 + 0.519659CMC^2 - 0.491364KG^2 - 0.046214DAT^2 - 4.64545DAV^2$$

The interactive effect of process variables (figure 3& 4) depicted that the minimum of L* value (33.98) was obtained at formulation 50:30:20 (Maizeflour:Ragiflour:Quinova flour) blend ratio, 4g CMC per 100g of blend ratio, 2g Karaya Gum per 100g of blend ratio, 60 ^{0}C drying air temperature and 1.0 m/sec. air flow rate. The maximum of L* value (44.7) was obtained for formulation 50:10:40 (Maize flour: Rag flour: Quinova flour) blend ratio, 4g CMC per 100g of blend ratio, 2g Karaya Gum per 100g of blend ratio, 60 ^{0}C drying air temperature and 1.0 m/sec. air flow rate. The result indicated that L* value increases with decrease in ragi flour in blend ratio. Drying air temperature affects quadratically lightness of pasta samples.

Effect of process parameters on b*(Yellowness):

The regression equation describing the effect of the process variables on b*of pasta samples in terms of actual level of the variables are given as:

$$Colour,\ b^* = -9.75420 - 0.307447FMF + 0.769432CMC + 1.67053KG + 0.909492DAT + 0.481061DAV + 0.003125FMF * CMC + 0.034250FMF * KG + 0.000975FMF * DAT + 0.099500FMF * DAV - 0.143750CMC * KG - 0.023125CMC * DAT - 0.552500CMC * DAV - 0.049250KG * DAT + 0.935000KG * DAV - 0.045500DAT * DAV + 0.009959FMF^2 + 0.156477CMC^2 + 0.150909KG^2 - 0.006191DAT^2 + 0.423636DAV^2$$

The interactive effect of process variables (figure 5 & 6) depicted that the minimum of b* value (17.71) was obtained at formulation 50:10:40 (Maize flour: Ragi flour: Quinova flour) blend ratio, 4g CMC per 100g of blend ratio, 2g Karaya Gum per 100g of blend ratio, 60 ^{0}C drying air temperature and 1.0 m/sec. air flow rate. The maximum of b* value (23.72) was obtained for formulation 50:30:20 (Maizeflour:Ragiflour:Quinova flour) blend ratio, 4g CMC per 100g of blend ratio, 2g Karaya Gum per 100g of blend ratio, 60 ^{0}C drying air temperature and 1.0 m/sec. air flow rate. The result indicated that b* value increases with increase in quinova flour in blend ratio. Drying air temperature negatively affects linearly yellowness values of pasta samples.

Effect of process parameters on YI (Yellowness Index):

The regression equation describing the effect of the process variables on YI (Yellowness Index) of pasta samples in terms of actual level of the variables are given as:

$$YI = +269.15577 - 1.63618FMF + 18.95039CMC - 1.41276KG - 7.01960DAT - 47.15097DAV + 0.116673FMF * CMC + 0.175870FMF * KG - 0.009264FMF * DAT + 0.649343FMF * DAV - 2.05536CMC * KG - 0.256660CMC * DAT - 0.896448CMC * DAV - 0.115237KG * DAT + 7.92673KG * DAV + 0.046108DAT * DAV + 0.077527FMF^2 - 0.255623CMC^2 + 1.52433KG^2 + 0.068378DAT^2 + 10.45187DAV^2$$

The interactive effect of process variables (figure 7 & 8) depicted that the minimum of YI value (56.60) was obtained at formulation 50:10:40 (Maizeflour:Ragiflour:Quinova flour) blend ratio, 4g CMC per 100g of blend ratio, 2g Karaya Gum per 100g of blend ratio, 60 ^{0}C drying air temperature and 1.0 m/sec. air flow rate. The maximum of YIvalue (99.72) was obtained for formulation 50:30:20 (Maizeflour:Ragiflour:Quinova flour) blend ratio, 4g CMC per 100g of blend ratio, 2g Karaya Gum per 100g of blend ratio, 60 ^{0}C drying air temperature and 1.0 m/sec. air flow rate. The result indicated that YI value increases with increase in ragi flour in blend ratio.

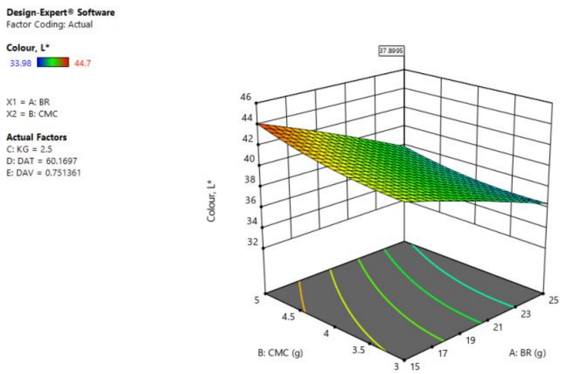


Fig.3: Interaction effects of BR and CMC on L*

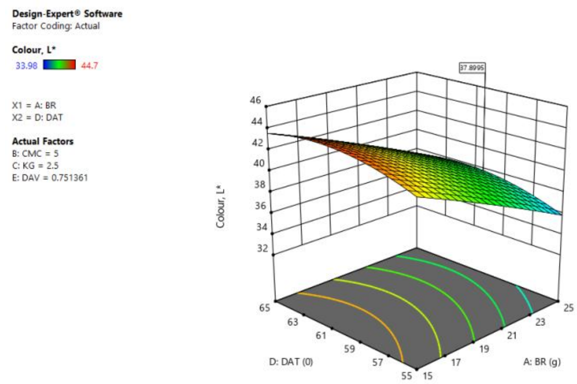


Fig.4: Interaction effects of BR and DAT on L*

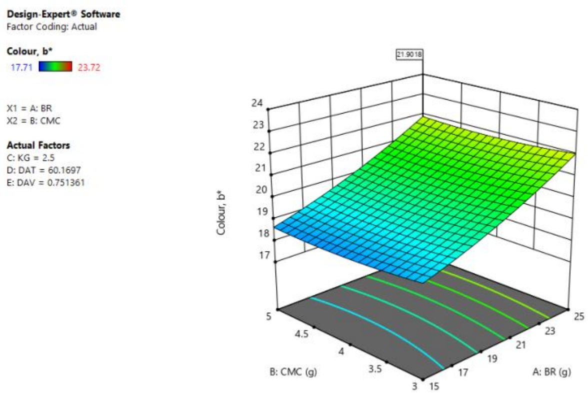


Fig.5: Interaction effects of BR and CMC on b*

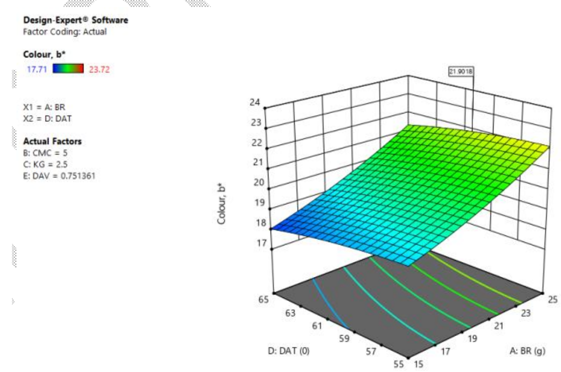
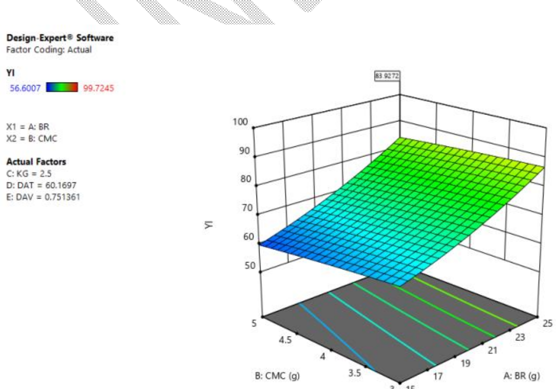


Fig.6: Interaction effects of BR and DAT on b*



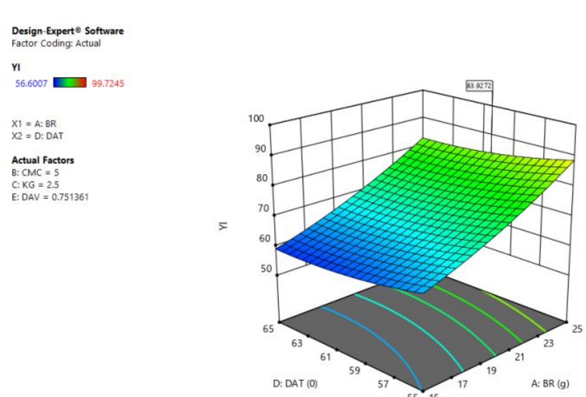


Fig.7: Interaction effects of BR and CMC on YI

Fig.8: Interaction effects of BR and DAT on YI

Optimization of parameters

Numerical optimization was carried out using design expert software for the process parameters to obtain the optimum product with reference to colour parameters. The desired goals for each factor and responses were chosen. The software generated optimum conditions of process variables with the predicted values of responses having the maximum desirability value, along with the maximum L*, maximum b* and maximum YI was selected as optimum for pasta samples. Based on the obtained results optimum value of independent variables and their responses suggested by the software are given in the Table 1.

Table1. Optimum Values of independent variables and their responses

BR	CMC	KG	DAT	DAV	L* (Lightness)	b* (Yellowness)	YI (Yellowness Index)	Desirability
25.0	5.0	2.50	59.949	0.767	37.851	21.927	84.102	0.545

4. Conclusion

Pasta is a staple food in many countries; however, it is still considered a snack food in India. Due to the increased market demand for pasta, production has to be done with increased nutritional quality. The study has shown that acceptable pasta samples with a high yellowness index could be produced using gluten-free flours of maize, ragi, and quinova with high nutritional values. Pasta samples prepared following optimized formulation 50:25:25 (Maize flour:Ragi flour:Quinova flour) blend ratio, 5g CMC per 100g of blend ratio, 2.5g Karaya Gum per 100g of blend ratio, 60 ^{0}C drying air temperature and 0.78 m/sec. air flow rate provided optimum values of colour parameters. The optimum values for L*, b* and YI were found 37.851, 21.927 and 84.102 respectively with overall desirability 0.545.

References:

1. Clydesdale, F. M. (1978). Colorimetry-methodology and applications. Critical Reviews in Food Science and Nutrition, 10(3), 243–301.
2. DayakarRao B., Bhaskarachary K., Arlene Christina G.D., Sudha Devi G., Tonapi VA, (2017), Nutritional and Health benefits of Millets. ICAR_Indian Institute of Millets Research (IIMR) Rajendranagar, Hyderabad, PP 112, ISBN: 81-89335-68-5.
3. Devaraju, B., Begum, J., &Vidhya, K. (2006). Storage & Microbial quality of pasta from Finger Millet composite Flour. Indian food packer, 60(6), 141.
4. Feillet, P. and Dexter, J.E. (1996) Quality Requirements of Durum Wheat for Semolina Milling and Pasta Production. In: Kruger, J.E., Matsuo, R.R. and Dick, J.W., Eds., Pasta and Noodle Technology, AACC Inc., 95-123.

5. Francis, F. J. (1995). Quality as influenced by color. Food Quality and Preference, 6(3), 149–155
6. He, L., Zhang, B., Wang, X., Li, H., & Han, Y. (2015). Foxtail millet: nutritional and eating quality, and prospects for genetic improvement. Frontiers of Agricultural Science and Engineering, 2(2), 124-133.]
7. Krishnan R, Dharmaraj U and Malleshi NG (2012). Influence of decortication, popping and malting on bio-accessibility of calcium, iron and zinc in finger millet. LWT-Food Science and Technology, 48(2): 169–174.
8. Monica A, M. Cristina Nicoli , Roberto Massini and Carlo R. L. (1999). Effects of drying processing on the Maillard reaction in pasta; Food Research International, 32 , 193-199
9. Pankaj B. Pathare ,Umezuruike Linus Opara and Fahad Al-Julanda Al-Said (2013). Colour Measurement and Analysis in Fresh and Processed Foods: A Review; Food Bioprocess Technol, 6:36–60
10. Rhim J. W., Gennadios A., Handa A., Weller C. L. and Hanna M.A. (2000). Solubility, Tensile, and Color Properties of Modified Soy Protein Isolate Films; *J. Agric. Food Chem.* , 48, 10, 4937–4941
11. Sakhare, S. D., Inamdar, A. A., Soumya, C., Indrani, D., &Rao, G. V. (2014). Effect of flour particle size on microstructural, rheological and physico-sensory characteristics of bread and south Indian parotta. Journal of food science and technology, 51(12), 4108-4113.
12. Svec I., Hruskova M., Vítova M., Sekerova H. (2008). Colour evaluation of different pasta samples. Czech J. Food Sci., 26: 421–427.