Original Research Article

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Effect of Material Parameters and Machine Parameters on Nutrient Content of Extrudates Prepared from Different Blends of Sattu and Kodo

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ABSTRACT

Keywords

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In the present study extrudates were prepared to identify the optimum machine parameters and prepare good quality ready to eat extruded snacks from a suitable blend of sattu and kodo. Fibre content remain unchanged with increase in proportion of kodo flour in the different feed blends and increases with increase in moisture content of feed, with increase in barrel temperature, with increase in die head temperature. The fibre content increases with increase in screw speed. Calcium content was found to increase with increase in proportion of kodo flour in the different feed blends. The maximum value of calcium content of extrudates was found to be 7.9% whereas its minimum value was 6.55%. Iron content decrease with increase in sattu content of blend and increase with increase in barrel temperature, die head temperature and screw speed, maximum value of iron content was found 6.6 and minimum 4.9.

Introduction

Extrusion aims at producing a voluminous, expanded, crispy product resembling a baked product. There is no principal limitation in terms of the raw materials, which can be used for extrusion. Anti-nutritive compounds can be reduced during extrusion to provide safer and more nutritious foods (Harper, 1981). Using extrusion cooking technology good

blend ratios optimum machine and process parameters can be identified to fortify the kodo with sattu (mixture of roasted gram wheat and barley powder in the ratio of 80:10:10 for ready to eat extruded snacks.

The ability of extruders to blends diverse ingredients in novel foods can also be exploited in the developing functional foods market. Functional ingredients such as sattu

(mixture of roasted gram powder, wheat powder and barley powder in the ratio of 80:10:10) has been taken. Simple single-screw extrusion is relatively more versatile, inexpensive and easy to maintain processes, which can be applied to take advantage of indigenous crops such as cereals, millets and pulses crops.

Extrusion is the process of pumping thick viscous liquid. The device used for the process is known as extruder. Extruder is a cooker where pasty, semisolid materials may be cooked, mixed and/or concentrated. This is a type of heat exchanger that is common for producing sweetmeat, ready to eat cereals etc.

A screw type device is commonly used for extrusion. It consists of flighted Archimedes spiral that rotates inside a tightly fitting stationary barrel. It is capable of mixing, heating, cooking and shaping in concert to its pumping action. The cooking extruder combines several unit operations-mixing, cooking, kneading, shear, cooling, and/or final shaping/ forming.

The combination of operations is possible because of a multitude of controllable variables such as feed rate, total moisture in barrel, screw speed, barrel temperature, screw profile, and die configuration. The energy input comes mainly from the conversion of mechanical to thermal energy. Extruded food materials undergo various transformations including starch gelatinization, fragmentation and protein denaturation, which affect the properties of the extrudates.

Materials and Methods

Sattu and kodo were procured from local market. After initial removal of foreign materials, all the mixture of sattu powder and kodo flour) were blended in predetermined proportions and mixed thoroughly in mixer

and then they were fed to the Brabender single screw extruder at specific moisture content for making the extruded product at different predetermined set of operations.

The experiments were carried out to find out the effect of different levels of processing parameters namely moisture contents of feed (8, 10, 12, 14 and 16%), blend ratios i.e. sattu: kodo (70:30, 60:40, 50:50, 40:60 and 30:70), the proportion of roasted gram, wheat, barley powder in a constant proportion i.e. 80:10:10.

The machine parameters that were varied to get the appropriate temperature (160, 170, 180, 190 and 200 °C) and screw speed (70, 90, 110, 130 and 150 rpm) on textural properties namely hardness, crispness, and cutting strength of extrudates

Results and Discussion

Fibre content of extrudates

The multiple regression analysis for fibre content of extrudates versus feed moisture content (MC_F), blend ratio (BR), barrel temperature (T_{Brl}), die head temperature (T_{Die}) and screw speed (S_S) was done using CCRD and fitting of second degree polynomial equation for representative response surface of data resulted in the development of following model;

$$\begin{aligned} \text{Fibre} = & 19.5 - 6.49 \times MC_F - 0.17 \times BR \\ & - 2.59 \times T_{brl} - 1.25 \times T_{die} + 2.28 \times SS - 8.78 \times \\ & MC_F \times BR + 5.65 \times MC_F \times T_{brl} + 3.10 \times MC_F \\ & \times T_{die} - 3.88 \times MC_F \times SS - 8.17 \times BR \times T_{brl} - \\ & 1.78 \times BR \times T_{die} + 1.20 \times BR \times SS + 1.21 \times T_{brl} \\ & \times T_{die} - 4.81 \times T_{brl} \times SS + 7.36 \times T_{die} \times SS + \\ & 5.59 \times MC_F^2 + 3.40 \times BR^2 + 2.22 \times T_{brl}^2 + \\ & 2.22 \times T_{die}^2 + 5.55 \times SS^2 \dots 4.10 \end{aligned}$$

The R^2 had a value of 1.000 for the model. The brief information are presented in Table-1.

Regression coefficient and standard error of second order mathematical model are also reported (Table-1), the significance of each terms is also reported. The positive coefficient at linear level indicated that there was increase in response with increase in level of selected parameters and vice versa. Negative quadratic terms indicated that the maximum value of the response was at the centre point while positive quadratic term gave the minimum response.

The standard deviation, coefficient of variation, mean and predicted residual error sum of square (PRESS) values, coefficient of determination and predicted R^2 and adequate precision are presented in Table 4.

The response surface graphs of the model 1 are presented in Fig.1 to 10. It is clear from Fig.1 to 4 that there is virtually no change in the fibre content with change in blend ratio, barrel temperature, die head temperature and screw speed however there is slight change with the change in moisture content but it is very slow. From Fig.5 to 10, it can be said that there is increasing trend in the pattern of fibre content with increase in die head temperature, barrel temperature and screw speed.

Calcium content of extrudates

The multiple regression analysis for calcium content of extrudates versus feed moisture content (MC_F), blend ratio (B_R), barrel temperature (T_{Brl}), die head temperature (T_{Die}) and screw speed (S_S) was done using CCRD and fitting of second degree polynomial equation for representative response surface of data resulted in the development of following model;

$$\text{Calcium} = -0.29 - 0.01 \times MC_F + 0.07 \times BR \times 0.04 \times T_{brl} 0.02 T_{die} - 0.00 \times SS + 3.97 \times MC_F \times BR - 2.84 \times MC_F \times T_{brl} + 2.84 \times MC_F$$

$$\times T_{die} + 1.42 \times 10^{-18} \times MC_F \times SS - 7.94 \times BR \times T_{brl} + 7.94 \times BR \times T_{die} + 3.97 \times BR \times SS - 5.67 \times T_{brl} \times T_{die} - 2.84 \times T_{brl} \times SS + 2.84 \times T_{die} \times SS - 0.00 \times MC_F^2 - 1.83 \times BR^2 - 5.79 \times T_{brl}^2 - 5.79 \times T_{die}^2 - 1.45 \times SS^2 \dots 4.11$$

The R^2 had a value of 0.9992 for the model. The brief information are presented in Table-2.

Regression coefficient and standard error of second order mathematical model are reported in Table-2, the significance of each terms is also reported. The positive coefficient at linear level indicated that there was increase in response with increase in level of selected parameters and vice versa. Negative quadratic terms indicated that the maximum value of the response was at the centre point while positive quadratic term gave the minimum response.

The standard deviation, coefficient of variation, mean and predicted residual error sum of square (PRESS) values, coefficient of determination and predicted R^2 and adequate precision are given in Table 4. The response surface graphs of the model 4.11 are presented in Fig.11 to 20.

From Fig.11 to 14, it is clear that the calcium content is increasing with the increase in blend ratio of sattu and moisture content there is little change in calcium content of the extruder with the change in die head temperature, barrel temperature however as the screw speed is increasing the calcium content is also increasing Fig.19 to 20.

Iron content of extrudates

The multiple regression analysis for iron content of extrudates versus feed moisture content (MC_F), blend ratio (B_R), barrel temperature (T_{Brl}), die head temperature (T_{Die}) and screw speed (S_S) was done using CCRD

and fitting of second degree polynomial equation for representative response surface of data resulted in the development of following model;

$$\text{Iron} = 5.71 - 0.01 \times \text{MC}_F - 0.08 \times \text{BR} + 0.04 \times \text{T}_{\text{brl}} + 0.02 \times \text{T}_{\text{die}} - 0.00 \times \text{SS} + 3.97 \times \text{MC}_F \times \text{BR} - 2.84 \times \text{MC}_F \times \text{T}_{\text{brl}} + 2.84 \times \text{MC}_F \times \text{T}_{\text{die}} + 1.42 \times \text{MC}_F \times \text{SS} + 7.84 \times \text{BR} \times \text{T}_{\text{brl}} + 7.94 \times$$

$$\text{BR} \times \text{T}_{\text{die}} + 3.97 \times \text{BR} \times \text{SS} - 5.67 \times \text{T}_{\text{brl}} \times \text{T}_{\text{die}} - 2.84 \times \text{T}_{\text{brl}} \times \text{SS} + 2.84 \times \text{T}_{\text{die}} \times \text{SS} - 0.00 \times \text{MC}_F^2 - 1.83 \times \text{BR}^2 - 5.79 \times \text{T}_{\text{brl}}^2 - 5.79 \times \text{T}_{\text{die}}^2 - 1.45 \times \text{SS}^2 \dots 4.12$$

The R^2 had a value of 0.9995 for the model. The brief information are presented in Table 4.

Table.1 Analysis of variance for fiber content of extrudates

Source	DF	SS	MSS	F	P
Regression	20	68.99	3.44	636.60	<0.0001
Residual	11	0	0		
Total	31	68.99			

Table.2 Analysis of variance for calcium content of extrudates

Source	DF	SS	MSS	F	P
Regression	20	10.42	0.521	766.01	<0.000
Residual	11	0.007	0.000		
Total	31	10.428			

Table.3 Analysis of variance for iron content of extrudates

Source	DF	SS	MSS	F	P
Regression	20	16.85	0.84	1238.74	<0.00
Residual	11	0.007	0.00		
Total	31	16.86			

APPENDIX B

Table.4 The standard error, mean, coefficient of variation, predicted residual error of sum of squares (PRESS), coefficient of determination, adjusted and Pred R-Squared and adequate precision values for developed models

Model No.	St. deviation	Mean	C.V.%	PRESS	R2	Adj. R2	Pred. R2	Adeq Precision
4.10	0	11.10625	0	0	1	1	1	--
4.11	0.026081	7.23125	0.360672	0.190934	0.999283	0.997978	0.981692	125.6387
4.12	0.026081	5.825	0.447744	0.190934	0.999556	0.998749	0.988675	158.3431

Fig.1 Effect of moisture content and blend ratio on fibre content of extrudates

Fig.2 Effect of moisture content and barrel temperature on fibre content of extrudates

Fig.3 Effect of moisture content and die head temperature on fibre content of extrudates

Fig.4 Effect of moisture content and screw speed on fibre content of extrudates

Fig.5 Effect of blend ratio and barrel temperature on fibre content of extrudates

Fig.6 Effect of blend ratio and die head temperature on fibre content of extrudates

Fig.7 Effect of blend ratio and screw speed on fibre content of extrudates

Fig.8 Effect of barrel temperature and die head temperature on fibre content of extrudates

Fig.9 Effect of barrel temperature and screw speed on fibre content of extrudates

Fig.10 Effect of die head temperature and screw speed on fibre content of extrudates

Fig.11 Effect of moisture content and blend ratio on calcium content of extrudates

Fig.12 Effect of moisture content and barrel temperature on calcium content of extrudates

Fig.13 Effect of moisture content and die head temperature on calcium content of extrudates

Fig.14 Effect of moisture content and screw speed on calcium content of extrudates

Fig.15 Effect of blend ratio and barrel temperature on calcium content of extrudates

Fig.16 Effect of blend ratio and die head temperature on calcium content of extrudates

Fig.17 Effect of blend ratio and screw speed on calcium content of extrudates

Fig.18 Effect of barrel temperature and die head temperature on calcium content of extrudates

Fig.19 Effect of barrel temperature and screw speed on calcium content of extrudates

Fig.20 Effect of die head temperature and screw speed on calcium content of extrudates

Fig.21 Effect of moisture content and blend ratio on iron content of extrudates

Fig.22 Effect of moisture content and barrel temperature on iron content of extrudates

Fig.23 Effect of moisture content and die head temperature on calcium content of extrudates

Fig.24 Effect of moisture content and screw speed on calcium content of extrudates

Fig.25 Effect of blend ratio and barrel temperature on iron content of extrudates

Fig.26 Effect of blend ratio and die head temperature on iron content of extrudates

Fig.27 Effect of blend ratio and screw speed on iron content of extrudates

Fig.28 Effect of barrel temperature and die head temperature on iron content of extrudates

Fig.29 Effect of barrel temperature and screw speed on iron content of extrudates

Fig.30 Effect of die head temperature and screw speed on iron content of extrudates

The standard deviation, coefficient of variation, mean and predicted residual error sum of square (PRESS) values, coefficient of determination and predicted R^2 and adequate precision are given in Table 4.

The response surface graphs of the model 4.12 are presented in Fig. 21 to 30. From Fig. 21 to 30 it is clear that the iron content is increasing with increase in moisture content,

screw speed, barrel temperature, die head temperature, however the iron content remain unchanged with change in blend ratio.

References

Harper J.M. (1981).Extrusion of Foods, Boca Raton, FL, CRC Press, Inc.

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