Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 5, Issue, 10, pp.2739-2743, October, 2013

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

TEXTURAL PROPERTIES OF DEFATTED SOY-RICE BASED EXTRUDATES

[1]*Sanjeev Kumar Garg and [2]Daya S. Singh

[1]Department of Post Harvest Process and Food Engineering, College of Agriculture Ganjbasoda, JNKVV, Jabalpur (M.P) India
[2]Department of Farm Engineering, Institute of Agricultural Sciences Banaras Hindu University, Varanasi-221 005, India

ARTICLE INFO

Article History:
Received 29th July, 2013
Received in revised form
10th August, 2013
Accepted 11th September 2013
Published online 10th October, 2013

Key words:
Extrusion, Extrusion Cooking,
Ready-to-eat breakfast cereal,
Defatted soy-fortified rice based extruded snacks, Crispiness, Hardness,
Cutting strength.

ABSTRACT

Extrusion cooking is a popular means of preparing snack foods and ready-to-eat breakfast cereals using starch-based raw materials. Snacks contribute an important part of many consumers in daily nutrient and calories intake. A ready to eat extruded food was developed using brabender single screw laboratory extruder by incorporation of defatted soy flour with rice flour. The effect of moisture content (12 to 24 per cent (w.b.), defatted soy flour in the blend ratio (10 to 26 per cent) and die head temperature (160 to 200^{0}C) were studied on the textural quality such as crispness, hardness and cutting strength of the extruded snacks. It was observed that at the lower value of moisture content (15 per cent) of feed and defatted soy flour to rice flour blend ratio (14:86) the crispness of snacks was highest. The crispness decreased up to 185^{0}C die head temperature beyond 185^{0}C temperature the crispness increased. Similarly the crispness of the product gradually decreased by increasing or decreasing defatted soy flour to rice flour ratio blending ratio beyond 14:86. The lowest hardness was obtained nearly at 14:86 defatted soy flour to rice flour blend ratio and 15 per cent moisture content of feed as the value of moisture content of feed increased the value of hardness also increased. The minimum cutting strength was observed at 170^{0}C die head temperature. Further it was observed that the maximum value of crispness lies nearly higher side of die head temperature and lowest hardness and cutting strength was obtained at lowest value of moisture content i.e. 15 per cent and 14:86 blend ratio.

INTRODUCTION

Extruders are complex devices which cause significant changes in food ingredients under conditions of high temperature, shear and pressure maintained for only short period of time (Harper 1981). Extruders are used in the food industries for the production of snacks, breakfast cereals, bread crumbs etc., and non food industries for the production of plastics materials. Extruded snack foods have become an integral part of the eating habits of the majority of the world's population. The extrusion technology allows to process a wide range of food raw materials to making good quality balanced food with reference to tasted, nutrition and shelf life. Soybean (*Glycine max* L.) is one of the richest sources of protein and can be effectively utilized for nutritional improvement of cereal-based extrudates (Kulkarni and Joshi 1992). Emergence and availability of defatted soy flour has made it possible to use it as a rich protein source for improving the nutritional status of extruded foods. Harper (1981) reported the optimal incorporation of full fat soy flour and defatted soyflour in snacks to increase protein quality. Patil *et al*., (1990) studied the dry extrusion cooking for production of snacks with full fat soy-rice blend and soy sorghum blends at 30 : 70 ratio. Singh *et al* (2005) studied the effect of extrusion processing parameters of blends composed of soy-sorghum at five levels of blend ratio (5, 10, 15, 20 & 25 per cent of soybean in blend), three levels of barrel temperature (80, 90 & 100^{0}C) and three levels of moisture contents 15, 20 & 25 per cent in a wenger X-5 single screw laboratory extruder for preparation of ready to eat snack food. Garg *et al*. (2005) studied the effect of moisture content, blending ratio and barrel temperature and extrusion parameters of the Bengal gram fortified sorghum based snacks were investigated and reported that the mass flow rate was increased with increasing moisture content and blend ratio and vice versa. Singh *et al*. (2006) studied the effect of major processing parameters on the quality of extrudates made out of soy-kodo blends. They found that the best quality extrudates were obtained at 20 per cent blending of soybean, 15 per cent moisture content and 85^{0}C temperature was best followed by snack prepared with 10 per cent blending of soybean, 15 per cent moisture content and 95^{0}C temperature. Rice (*Oryza sativa* L.) flour is an important ingredient for many ready-to-eat snacks and rice is one of the leading food crop of over half of world's population. It is a staple food of East, South East and South Asia where 90 per cent of the world's rice crop is produced and consumed (Juliano 1972). Chauhan and Bains (1998) studied the effect of some extruder variable on physico-chemical properties of extruded rice-legume blends. Jha and Prasad (2003) studied the extrusion cooking of rice and mung blend with salt and sugar. They found that die temperature had maximum influence on expansion ratio where as feed moisture content had the maximum influence on bulk density and hardness of extruded products. They also reported that rice and mung blend extrusion with 2 per cent salt (for salt product) and with 6 per cent sugar (for sweet products) was found to produce most acceptable quality products. The present study was undertaken to see the effect of moisture content, blend ratio screw speed (S_S)and temperature (barrel and die head) on the textural properties (crispiness, hardness and cutting strength) of rice, defatted soy flour based ready-to-eat extrudates.

MATERIALS AND METHODS

A single-screw, laboratory extruder model Brabender D47055 DUISBURG was used in the study, the extruder consisted to grooved

***Corresponding author: Sanjeev Kumar Garg,** *Department of Post Harvest Process and Food Engineering, College of Agriculture Ganjbasoda, India*

barrel covered with heating and cooling elements. The constructional elements of the extruder are, motor and gear unit, coupling, loading unit, extruder barrel with screw and control cabinet. The length to – diameter (L/D) ratio of the extruder was 20 : 1. During experimentation the compression ratio (3:1), temperature of barrel zone I (90^0C) and barrel zone II (120^0C) were kept constant. The defatted soy-flour and rice flour were taken as a raw material for the present study and procured from local market. The experimental design is dependent on the symmetrical selection of variable and their increment about the centre composition. These levels of variables were selected to be with in the range of reasonable formulations. The selected levels were also based on the conclusions of previous studies by referred authors and preliminary trails. The experiments were conducted on Response surface methodology based central composite rotatable design (CCRD). The CCRD can be fitted into a sequential programme starts with on exploratory 2 K factorial to which a linear response surface is fitted (Cochran and Cox, 1957). The data obtained from the experiment outlined were processed in Design expert 7.0.0. The adequacy of model was tested using F ratio and coefficient of determination R^2. Moisture contents of feed (12, 15, 18, 21 & 24 per cent), blend ratio i.e. defatted soyflour – rice (10 : 90, 14 : 86, 18 : 82 22: 78 and 26 : 74), Screw Speed (100 110 120 130 140 rpm) barrel temperature (100, 110, 120, 130 & 1400C) and die head temperature (160, 170, 180, 190 & 200^0C) were taken for experimentation. Texture analyser was used to study the effect on crispness, hardness and cutting strength of randomly selected samples from the extruded mass with the help of using Warner blade and cylindrical probes. In order to precisely determine the textural properties and ensure uniformity in methodology standard methods as recommended for texture test were used. The Pre-test speed was 5.0 mm/s, test speed was 2.0 mm/s post test speed 10 mm/s distance 10.0 mm, trigger force auto-25g and data acquisition rate 200 pps were used (Table 1).

Table 1. Average values of observed data during the textural analysis of defatted soy flour- rice blend

S.No.	MC	BR	BT	DT	SS	Crispiness	Hardness	Cutting strength
1	15	14	110	170	130	62	3.67	2.62
2	21	14	110	170	110	42	5.02	6.12
3	15	22	110	170	110	59	3.8	4.5
4	21	22	110	170	130	41	4.44	6.44
5	15	14	130	170	110	63	3.49	3.49
6	21	14	130	170	130	47	4.56	4.65
7	15	22	130	170	130	66	3.72	2.72
8	21	22	130	170	110	43	4.9	3.42
9	15	14	110	190	110	62	3.42	4.9
10	21	14	110	190	130	40	4.88	4.01
11	15	22	110	190	130	61	3.79	4.88
12	21	22	110	190	110	49	4.98	4.77
13	15	14	130	190	130	63	3.77	3.1
14	21	14	130	190	110	40	4.98	3.8
15	15	22	130	190	110	64	3.8	4.98
16	21	22	130	190	130	43	5.95	5.9
17	12	18	120	180	120	76	2.95	4.65
18	24	18	120	180	120	30	6.95	5.09
19	18	10	120	180	120	58	3.24	3.14
20	18	26	120	180	120	50	3.56	3.65
21	18	18	100	180	120	52	3.01	3.21
22	18	18	140	180	120	50	3.37	4.37
23	18	18	120	160	120	67	2.69	3.31
24	18	18	120	200	120	54	3.31	2.96
25	18	18	120	180	100	59	3.33	3.25
26	18	18	120	180	140	64	3.25	3.33
27	18	18	120	180	120	58	3.64	3.35
28	18	18	120	180	120	52	3.35	3.64
29	18	18	120	180	120	56	3.49	3.76
30	18	18	120	180	120	55	3.76	3.49
31	18	18	120	180	120	54	3.32	2.8
32	18	18	120	180	120	51	3.46	3.24

RESULT AND DISCUSSION

The extruded product from defatted soy flour – rice blends was prepared on Brabender single screw laboratory model. The effect of variable on response were analysed with the ANOVA to check the significance of parameter. Efforts were made to fit the second degree polynomial models representing the response surface analysis of the data. *Crispiness* : The observed data showed that crispness of extrudates was highest at 12 per cent feed moisture content defatted soyflour-rice blend ratio 18 : 82, barrel temperature 120^0C and 180^0C die head temperature. Regression analysis of crispness versus feed moisture content (MC_F) blend ratio (B_R), barrel temperature (T_{Brl}), die head temperature (T_{Die}) and screw speed (S_S) yielded following polynomial model.

$$\text{Crispiness} = 15.043+4.743\ MC_F -1.994\ B_R +4.688\ T_{Brl} -1.194\ T_{Die} - 1.528\ S_S -0.11\ MC_F^{\ 2} -0.046\ B_R^{\ 2} -0.015\ T_{Brl}^{\ 2} +0.009\ T_{Die}^{\ 2} +0.011\ S_S^{\ 2} \quad \text{………..(1)}$$

The second order model obtained for estimated values (shown in Table 2) of crispiness. The coefficient of determination R^2 had a value of 0.938 for the model with F-value of 7.48 implies that the model terms had significant value of probability less than 0.05. In this model linear terms of moisture content of feed and barrel temperature are highly influencing coefficients for the model of crispness of extrudates. The response surface graph Fig. 1(a) showed the interactive effect of moisture content and die head temperature which depicted that at lower value of moisture content of feed the value of crispness is highest. Fig. 1(b) showed the relation ship of die head temperature and barrel temperature on crispness of extrudates. It is cleared from Figure that the maximum value of crispness lies at 120^0C barrel temperature and 185^0C die head temperature by increasing or decreasing the value of both barrel temperature & die head temperature the crispness gradually decreased. *Hardness* : It was minimum at 12 per cent feed moisture content, 18 : 82 defatted soy bean – rice blend ratio, 120^0C barrel temperature and 180^0C die head temperature. The second order model obtained for estimated values (shown in Table 3) of hardness is as follows

$$\text{Hardness} = 127.235-2.523\ MC_F -0.983\ B_R -0.493\ T_{Brl} -0.402\ T_{Die} - 0.512\ S_S +0.055\ MC_F^2 +0.007\ B_R^2 +0.0006\ T_{Brl}^2 +0.00009\ T_{Die}^2 +0.0008\ S_S^2 \quad \text{… (2)}$$

Table 2. Regression coefficient of second order mathematical model for crispness

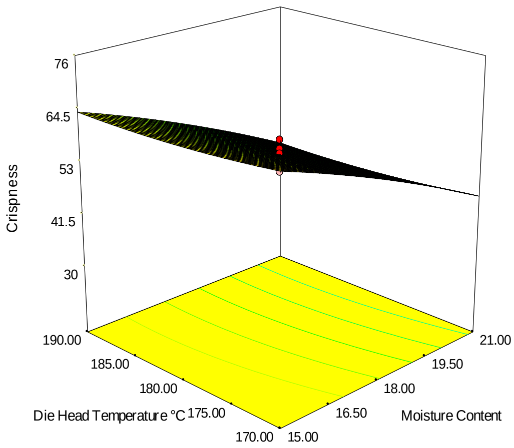
Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High
Intercept	54.98864	1	1.743256	51.15175	58.82552
A-M.C.	-10.2917	1	0.89214	-12.2553	-8.32808
B-B.R.	-0.375	1	0.89214	-2.33859	1.588587
C-B.T.	0.375	1	0.89214	-1.58859	2.338587
D-D.T.	-1.125	1	0.89214	-3.08859	0.838587
E-S.S.	0.458333	1	0.89214	-1.50525	2.42192
AB	0.4375	1	1.092644	-1.96739	2.842393
AC	-0.6875	1	1.092644	-3.09239	1.717393
AD	-0.0625	1	1.092644	-2.46739	2.342393
AE	-0.4375	1	1.092644	-2.84239	1.967393
BC	-0.0625	1	1.092644	-2.46739	2.342393
BD	1.0625	1	1.092644	-1.34239	3.467393
BE	-0.5625	1	1.092644	-2.96739	1.842393
CD	-1.0625	1	1.092644	-3.46739	1.342393
CE	1.0625	1	1.092644	-1.34239	3.467393
DE	-1.0625	1	1.092644	-3.46739	1.342393
A^2	-0.98864	1	0.806971	-2.76477	0.787495
B^2	-0.73864	1	0.806971	-2.51477	1.037495
C^2	-1.48864	1	0.806971	-3.26477	0.287495
D^2	0.886364	1	0.806971	-0.88977	2.662495
E^2	1.136364	1	0.806971	-0.63977	2.912495

Table 3. Regression coefficient of second order mathematical model for hardness

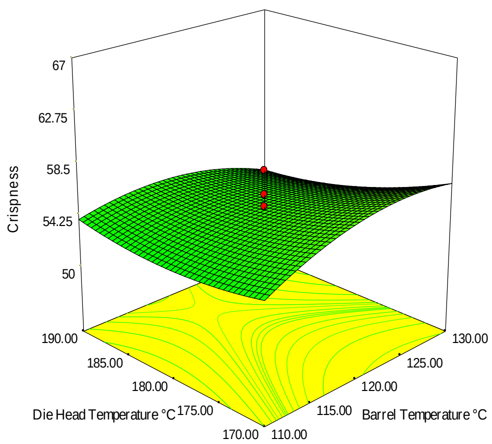
Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High
Intercept	3.368523	1	0.216835	2.891271	3.845774
A-M.C.	0.760417	1	0.110969	0.516175	1.004658
B-B.R.	0.092917	1	0.110969	-0.15132	0.337158
C-B.T.	0.07875	1	0.110969	-0.16549	0.322991
D-D.T.	0.13375	1	0.110969	-0.11049	0.377991
E-S.S.	0.009583	1	0.110969	-0.23466	0.253825
AB	0.004375	1	0.135909	-0.29476	0.303508
AC	0.060625	1	0.135909	-0.23851	0.359758
AD	0.110625	1	0.135909	-0.18851	0.409758
AE	-0.03063	1	0.135909	-0.32976	0.268508
BC	0.096875	1	0.135909	-0.20226	0.396008
BD	0.084375	1	0.135909	-0.21476	0.383508
BE	0.028125	1	0.135909	-0.27101	0.327258
CD	0.105625	1	0.135909	-0.19351	0.404758
CE	0.079375	1	0.135909	-0.21976	0.378508
DE	0.126875	1	0.135909	-0.17226	0.426008
A^2	0.496477	1	0.100375	0.275553	0.717402
B^2	0.108977	1	0.100375	-0.11195	0.329902
C^2	0.056477	1	0.100375	-0.16445	0.277402
D^2	0.008977	1	0.100375	-0.21195	0.229902
E^2	0.081477	1	0.100375	-0.13945	0.302402

Table 4. Regression coefficient of second order mathematical model for cutting strength

Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High
Intercept	3.2675	1	0.267302	2.697758	3.837242
A-M.C.	0.366667	1	0.136796	0.075092	0.658241
B-B.R.	0.2475	1	0.136796	-0.04407	0.539075
C-B.T.	-0.16083	1	0.136796	-0.45241	0.130741
D-D.T.	0.07	1	0.136796	-0.22157	0.361575
E-S.S.	-0.0625	1	0.136796	-0.35407	0.229075
AB	-0.06375	1	0.167541	-0.42085	0.293354
AD	-0.4175	1	0.167541	-0.7746	-0.0604
AE	0.465	1	0.167541	0.107896	0.822104
BD	0.2825	1	0.167541	-0.0746	0.639604
BE	0.3875	1	0.167541	0.030396	0.744604
CD	0.28875	1	0.167541	-0.06835	0.645854
A^2	0.485	1	0.123737	0.221261	0.748739
B^2	0.11625	1	0.123737	-0.14749	0.379989
C^2	0.215	1	0.123737	-0.04874	0.478739
D^2	0.05125	1	0.123737	-0.21249	0.314989
E^2	0.09	1	0.123737	-0.17374	0.353739



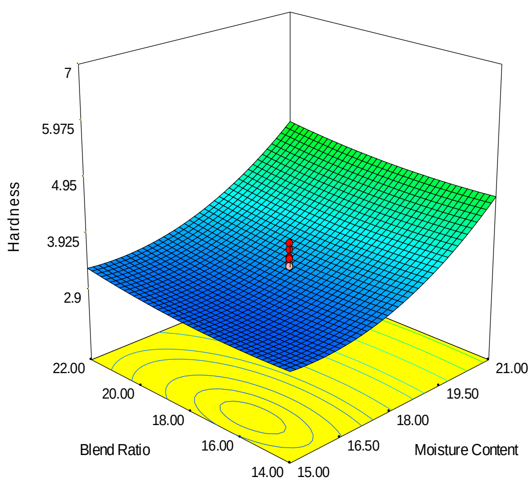
a)



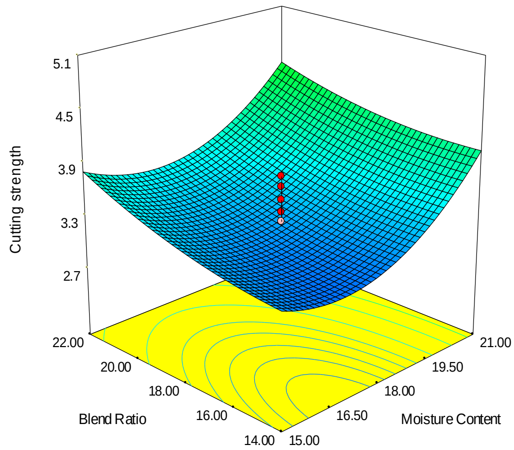
b)

Fig. 1. Response surface graph showing crispness of extrudates as affected by a) Feed moisture content and die head temperature b) Barrel temperature and die head temperature

The coefficient of determination R^2 had value of 0.877 for the model with F-value 3.93 implies that the model terms had significant effect. In the model, the coefficient of linear term of feed moisture content and blend ratio, quadratic term of moisture content had highly significant and influencing the hardness.



a)



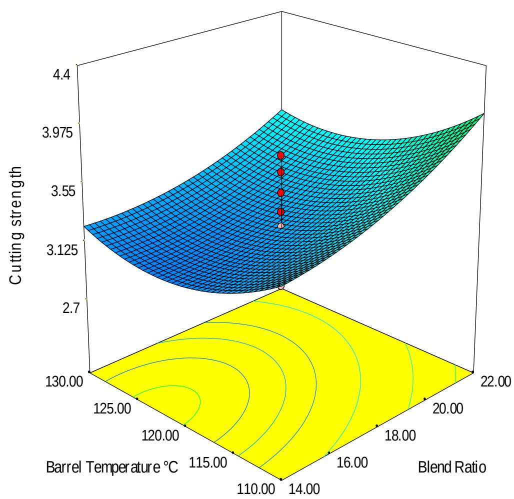
b)

Fig. 2. Response surface graph showing crispness of extrudates as affected by a) Feed moisture content and die head temperature b) Barrel temperature and die head temperature

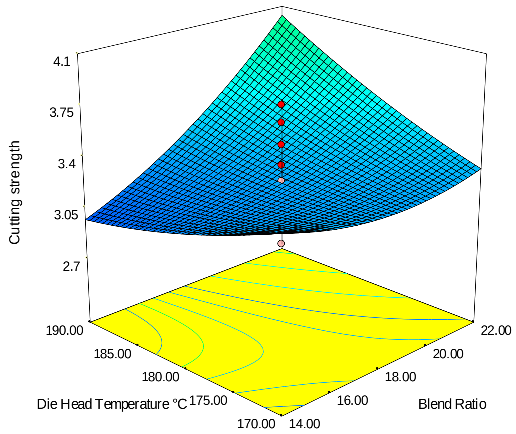
The response surface graph Fig. 2 showed that the lowest value of hardness linearly at lower side of both moisture content and blend ratio and when the value of moisture content of feed increases by keeping blend ratio at constant level, the value of hardness increased and when the value of blend ratio increased gradually by keeping moisture content of feed at constant level, the value of hardness also increased. *Cutting strength* : Cutting strength test was performed to had an idea of the resistance, which the snack may offer on first bite to the consumer. The mathematical model for the estimated value of cutting strength was fitted in full second order model.

Cutting strength = 201.469-0.837 MC_F -2.358 B_R-1.215 T_{Brl} -0.441 T_{Die} -0.963 S_S-0.014 MC_F x T_{Die} + 0.016 MC_F $_x$ S_S+0.01 B_R x S_S+0.054 MC_F^2+0.007 B_R^2 +0.002 T_{Brl}^2+0.0005 T_{Die}^2+0.0009 S_S^2 ……(3)

The coefficient of determination R^2 had value of 0.786 for the model and the F-value of 3.45. In this model linear terms of blend ratio had highly significant model term. Figure 3 showed the interactive effect of blend ratio with moisture content, barrel temperature and die head temperature. It was observed that there was strong correlation between the blend ratio and cutting strength of the extrudates. As the value of blend ratio increased the cutting strength also increased and maximum value of cutting strength was observed at lowest value of barrel temperature and maximum value of blend ratio.



a)



b)

Fig. 3. Response surface graph showing cutting strength of extrudates as affected by a) Feed moisture content and blend ratio b) Blend ratio and barrel temperature c) Blend ration and die head temperature

Conclusion

The extrusion cooking caused several changes in the physical, rheological and textural characteristics of defatted soy-fortified rice based extruded snacks. On the basis of the investigation carried out in this study, it was concluded that the moisture content of feed was found to have maximum influence on a crispness of extrudates whereas feed moisture content and blend ratio had the maximum influence on hardness of extruded products. Addition of higher ratio of defatted soy flour in rice gave the higher resistance which the snack offers on first bite to the consumer.

REFERENCES

Chauhan GS, Bains GS 1988. Effect of some extrudes variables on Physico – chemical properties of extended rice-legume blend. Food chemistry 27 : 213-224.

Cochran WG, Cox GM 1957. Experimental design. John wiley and Sons, (ASIA) Pet Ltd. Singapore.

Garg S.K, Daya S Singh and Mohan Singh 2005. Effect of moisture content and barrel temperature on extrusion parameters for preparation of bengal gram fortified sorghum based protein enriched ready-to-eat snacks. JNKVV Research Journal No. 39 (2): 78-81.

Harper J M 1981. Extrusion of foods. Vol II. CRC Press Inc. Florida.

Jha SK, Prasad S 2003. Studies on extrusion cooking of rice and mung blend with salt and sugar J. Food Science Technology 40 (3): 257-261.

Juliano BO 1972. The rice caryopsis and its composition in rice. Chemistry and technology, Houston DF (ed.). 1st edn. American association of cereal chemists, St. Paul Minnesota, 16-24.

Kulkarni SD, Joshi KC 1992. Possible effects of starch properties on few aspects of and product. Indian food packer 66 : 38-49.

Patil RT, Singh DS, Tribelhorn RE 1990. Effect of processing conditions on extrusion cooking of soy rice blend with a dry extrusion cooker. J Food Sci. technology. 27 : 376-378.

Singh Daya S, Garg SK, Singh Mohan, Goyal Neeraj 2006. Effect of major processing parameters on the quality of extrudates made out of soy-kodo blends. J Food Sci. Technology 43 (4) : 434-437.

Singh Daya S, Garg SK, Singh Mohan, Kalpana Duda 2005. Optimization of processing parameters of soy-sorghum blends extrudates. J. Agril. Engg. 42 (4) : 45-49.

****