International Journal of Sciences & Applied Research

www.ijsar.in

Development of cereal and legume based extrudates blended with Kokum rind powder

Sawant A. A.[1]*, N.J. Thakor[1], J.S.Dhekale[2]

[1]Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India.
[2]Assistant Professor of Statistics, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India.

Correspondence Address: *Sawant A.A., Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India.

Abstract

Extrusion cooking is one of the most efficient and versatile food processing technologies that can be used to produce pre-cooked and dehydrated foods which will break down the starch and denature protein, thereby improve digestibility. Extrusion cooking is predominantly a thermo-chemical processing operation that combines several unit operations including mixing, kneading, shearing, conveying, heating, cooling, forming and partial drying or puffing depending on the material and equipment used.

Cereals have been popular raw materials for extrusion because of their functional properties, low cost and ready availability. Extruded products are preferred by consumers because of their crispiness and good swelling properties. Hence the corn is basic raw material for extruded products. Horse gram used in diseases of stomach and it is very effective against vata and kapha. It also used in the treatment of urine stones.

Kokum fruits contain rich amounts of anti-oxidants that combine with free radicals and avoid oxidative damage to body cells. In the present investigation the efforts are made develop the cereal and legume based extrudates blending with kokum rind powder. The Extrusion barrel temperature 130^0C, 150^0C and 180^0C with screw speed 275 rpm and die diameter 5 mm. The flour combination of Corn: Rice: Horse gram at six different combinations are used and blended with 0,3,5, 7,10 and 15 % kokum rind powder. The moisture content, expansion ration, bulk density and hardness of the extrudates were determined. It was found that the extrudates prepared at 130^0C, screw speed 275 rpm and die diameter 5 mm and having flour combination (50:10:40) has maximum expansion ratio, highest bulk density and minimum hardness compared to other flour combination extrudates.

Keywords: Extrusion, antioxidant, crispiness, expansion ratio, bulk density, hardness

Introduction

Extrusion cooking is one of the most efficient and versatile food processing technologies that can be used to produce pre-cooked and dehydrated foods which will break down the starch and denature protein, thereby improve digestibility (Onyango *et al*., 2004). Extrusion combine the effect of heat with the act of extrusion and is an energy-efficient industrial process used widely in the production of blended foods, which is a much more controlled process than roasting and only takes 30-60 seconds (Serrano *et al*., 1997). Extrusion can produce foods free from microbial contamination that can be stored in preparation for famines and natural disasters. Processes can be developed to take advantage of indigenous crops such as beans, millets, and tuber crops (Camire, 1991).

Cereals have been popular raw materials for extrusion because of their functional properties, low cost and ready availability. Rice (*Oryza sativa*) is a staple food crop for a large part of the world's population, making it the second most consumed cereal grain. Rice provides more than one fifth of the calories consumed worldwide by humans. Rice contains approximately 7.37% protein, 2.2% fat, 64.3% available carbohydrate, 0.8% fiber and 1.4% ash content (Zhou *et al*., 2002).

Horse gram (*Macrotyloma uniflorum*, Fabaceae) is a pulse crop native to south-east Asian subcontinent and tropical Africa. It is the unexploited legume of the tropics and subtropics. It is also known as Gahat, Kulath or Kulthi,(huraLi) in India and is grown to be used as food and fodder. It is extensively cultivated, especially in dry areas of Australia, Burma, India, and Sri Lanka. The use of dry seeds of Horse gram is limited due to their poor cooking quality.

The chemical composition is similar with commonly cultivated legumes. Like other legumes, it is deficient in methionine and tryptophan. Comparatively, Horse gram seeds have higher trypsin inhibitor and hemagglutinin activities and polyphenols than other pulses like moth bean. Horse gram is good sources of iron and molybdenum. The iron content in horse gram is approximately 11.0 mg/100 g. Like other legume crop it is also rich in protein which is in range of 20-25%. (Borhade *et.al* 1983).

Kokum fruits contain rich amounts of anti-oxidants that combine with free radicals and avoid oxidative damage to body cells. They also support cell regeneration and repair, Kokum juice is especially popular during scorching summer months as the cooling properties of kokum, oil of the fruit is used as emollient and antiseptic. It also helps in bringing down fever and allergic reactions. Kokum seeds contain a high percentage of oil that freezes to form Kokum butter at atmospheric temperature. Kokum butter is extensively used in the pharmaceutical and cosmetic industry. Kokum butter is very soothing for burns, chaffed skin and scalds. Amrut kokum is a drink made of sugar syrup and is used to treat sunstroke.

Review of Literature

The research work done on extrusion cooking of different cereal legume blends and other raw materials by using single or twin screw extruders and the effects of independent variables on quality characteristics of extruded snack foods in India and abroad is reviewed here.

Maize (*Zea mays*) also known as corn, is one of the world's most versatile food grain. It contains 355 Kcal energy with 9.08 percent protein, 3.88 percent fat, 0.03 percent ash, 76.80 percent carbohydrates, vitamins and amino acids (Santosa *et al*., 2008).

Bohrade *et al.* (1983) mentioned that Horse gram and moth bean seeds contained 23.6% and 21.9% protein (N x 6.25), respectively. Both the legumes are rich sources of iron. The iron contents in horse gram and moth beans were 11.0 and 9.6 mg/100 g, respectively. NaCl at 10% (w/v) and Na_2CO_3 at 0.5% (w/v) were found to be effective in extracting 89% and 80% of moth bean and horse gram proteins from defatted flour The minimum solubility of horse gram proteins from defatted flour was at pH 4.0 whereas proteins from moth bean exhibited minimum solubility at pH 4.5. The water and oil absorption, and foaming capacities in case of horse gram and moth bean flours were 2.0 g/g and 2.2 g/g, 23.0% and 2.0 g/g, 1.6 g/g, 27.6%, respectively.

Mishra *et al. (2006)* studied the antioxidant activity of Garcinia indica (kokam) is an Indian spice. They observed that the antioxidant activity of aqueous and boiled extracts corresponding to their use in cooking and home remedies, besides the commercial kokam syrup. The assays employed are ORAC, FRAP, ABTS and the ability to inhibit lipid peroxidation in rat liver mitochondria. Kokam syrup and the two aqueous extracts had significant antioxidant effects in the above assays. They have high ORAC values (29.3, 24.5 and 20.3), higher than those reported for other spices, fruits and vegetables. The high antioxidant activity of kokam adds one more positive attribute to its known medicinal properties and hence its use in cooking, home-remedies and as a soft drink may be promoted.

Bisharat *et al.*, (2013) studied that Effect of extrusion conditions on the structural properties of corn extrudates enriched with dehydrated vegetables. It was observed that the extrudates obtained using a twin-screw extruder, operated at different conditions, including screw speed (150 rpm, 200 rpm, 250 rpm) and extrusion temperature (140 °C, 160 °C, 180 °C). The moisture content of the raw mixture was regulated in three levels (14%, 16.5%, 19%), whereas the concentration of the added ingredient was adjusted to 4%, 7% and 10% for broccoli and to 4%, 6% and 8% for olive paste. It was concluded that the Products with 14% moisture content and 4% material concentration that were extruded at the highest screw speeds (250 rpm) presented the highest degree of expansion.

Lazou *et al*. (2007) studied the effect of extrusion conditions, including feed rate (2.52–6.84 kg/h), feed moisture content (13–19% w. b.), screw speed (150 – 250 rpm) and extrusion temperature (150–230°C) on structural properties of corn-legume based extrudates. Porosity of extrudates was found to increase with temperature and residence time and to decrease with feed moisture content and corn to legume ratio. Screw speed did not affect extrudates properties. Comparatively, the usage of white bean in mixtures for the production of snacks, led to a product with higher porosity than those with other legumes**.**

Functional properties of flour and extrudates

Jyothi *et al.*, (2009) studied the Physical and Functional Properties of Arrowroot Starch Extrudates. Different levels of feed moisture (12%, 14%, and 16%) and extrusion temperatures (140, 150, 160, 170, 180, and 190 °C) were used for extrusion.. The expansion ratio of the extrudates ranged from 3.22 to 6.09. The water absorption index (6.52 to 8.85 g gel/g dry sample), water solubility index (15.92% to 41.31%), and oil absorption index (0.50 to 1.70 g/g) were higher for the extrudates in comparison to native starch (1.81 g gel/g dry sample, 1.16% and 0.60 g/g, respectively). Hardness and toughness were more for the samples extruded at higher feed moisture and lower extrusion temperature, whereas snap force and energy were higher at lower feed moisture and temperature. Extrusion cooking of arrowroot starch resulted in products with very good expansion, color, and lower digestibility, which can be exploited for its potential use as a snack food.

Blended Extruded

Altan *et al.,* (2008-a) studied twin screw extrusion of barley-grape pomace blends: Extrudate characteristics and determination of optimum processing condition. Grape pomace was mixed thoroughly with barley flour to the ratio of 0, 2, 6, 10, and 12.73 percent (db). It was observed that, blends of 2 percent grape pomace extruded at 160°C, 200 rpm and 10 percent grape pomace extruded at 160°C, 150 rpm had higher preference levels for parameters of appearance, taste, texture off-odor and overall acceptability.

Byung-Kee *et al*., (2004) studied extrusion on regular and waxy barley flour for production of expanded cereals. He studied the physical properties and effect of extrusion parameters. Blend was extruded in laboratory single screw extruder. Result showed that, flour from break roll mill stream of both regular and waxy barley produced extrudate with higher expansion index (2.73-3.02), higher water absorption in lower flour from reduction roll mill stream.

Gutkoski *et al*., (1999) studied the effects of initial moisture levels and extrusion temperatures on bulk density, water absorption and water solubility index, viscosity and color of extruded oat products. The result showed that the water absorption index of extrudates were relatively low (4.16–6.35 g gel/g sample) but increased as the initial moisture of the raw material as well as the extrusion temperature was elevated. Products with lower values of L * (luminosity) and greater values of a* (red) and b* (yellow) were obtained at high moisture rates and at a 120 ^{0}C extrusion temperature.

Atre (2012) studied the effect of extrusion processing on the color and antioxidant activity of rice extrudates by using single screw extruder at variable barrel temperature (120-180 ^{0}C), feed moisture (18-24 %) and kokum powder content (3-5 %). . The extrudates showed excellent red colour when extruded at temperatures upto 150 ^{0}C beyond which anthocyanins degraded resulting in lesser red colour. TPC and ORAC of samples showed maximum retention at 120 ^{0}C and 180 ^{0}C and minimum at 150 ^{0}C. The loss of TPC and ORAC varied from 33 to 61 % and 12 to 75 % respectively. Maximum breaking strength and maximum bulk density were observed at low temperature (120 ^{0}C) and high moisture (21 %). Expnasion index was maximum at high temperature (150 ^{0}C) and low moisture (18%). The effect of powder on bulk density and expansion index was not as prominent as that of temperature.

Materials and methods

The research work on cereal and legume based blended extrudates development was undertaken. To investigate the possibility of making extrudates using corn, rice and horse gram powder as base material, experiments were formulated for garcinia indica powder (kokum rind powder) in different proportions. The experimental work was carried out at College of Agricultural Engineering and Technology (CAET), Dapoli.

Twin screw extruder – Experimental Device

A co-rotating twin screw extruder (M/S. Basic Technology Private Ltd., Kolkata, India) with 3 mm diameter die was used for extrusion of maize, rice, and soybean flour with different proportion of finger millet. The screw had five sections with total 18 turns, out of these five sections, four sections had a length of 75 mm each and fifth section had 43.5 mm length. There was a clearance of 1.5 mm between barrel length and screw length. The extruder had self wiping system for easy cleaning of the machine. Twin-screw extruders differ from the single-screw extruder in terms of their processing capability and mechanical characteristics and are largely responsible for the increasing popularity of extrusion processing. The screws in a twin screw extruder are positioned adjacent to each other and are retained in position by profiled barrel housing, having a horizontal 'figure of eight' appearance. In the present investigation Twin Screw Extruder is used and parameters of the extruder are kept fixed such as feed rate 5 kg/hr, Barrel temperature 130^0C, 150^0C and 180^0C, Screw speed 275 rpm , die of 5.0 mm diameter and moisture content of mixture is 15 % (w.b).The flow process chart for preparation of extrudates by using Twin screw Extruder is given as below in fig.1.

Experimental design

In the present investigation maize is used as best supporting starchy material. Preliminary test of extrusion for 100 percent maize was carried out. Maize, rice and horse gram levels are varied in different proportion and the total composition is blended with kokum rind powder varied from 0, 3, 5, 7, 10 and 15 %. The detail of experimental treatments is given in Table 1.

Expansion Ratio (ER)

Radial expansion ratio (RER) is defined as the ratio of the diameter of the extrudate to the diameter of the die (Jyothi *et al*., 2009). It is a factor used to describe the expansion of the product. In order to determine the RER, the diameter of 20 randomly selected samples were measured from each run using a caliper and the average value was used.. The ratio between the diameter of the extrudate and the die hole (slit) will express as the expansion ratio.

$$ER = \frac{\text{Diameter of extrudate}}{\text{Diameter of die}}$$

Raw Material Ingredient

↓

Mixing different flours ((Ribbon Blender)

↓

Addition of water (upto 15 % m.c.)

↓

Mixing (Ribbon Blender)

↓

Sieving (0.25 SS Round sieve)

↓

Extrusion

↓

Cutting Extrudates (Cutter)

↓

Addition of spices

↓

Drying (Recirculatory Dryer)

↓

Packaging

↓

Extrudates Ready

Fig. 1: Flow Process chart for preparation of cereal and legume based extrudates.

Table 1: Details of Treatment combination.

No	Treatment	Maize	Rice	Horse gram	Kokum rind powder
1	T_1F_1	50	40	10	0
2	T_1F_2	50	30	20	0
3	T_1F_3	50	20	30	0
4	T_1F_4	50	10	40	0
5	T_2F_1	50	40	10	3
6	T_2F_2	50	30	20	3
7	T_2F_3	50	20	30	3
8	T_2F_4	50	10	40	3
9	T_3F_1	50	40	10	5
10	T_3F_2	50	30	20	5
11	T_3F_3	50	20	30	5
12	T_3F_4	50	10	40	5
13	T_4F_1	50	40	10	7
14	T_4F_2	50	30	20	7
15	T_4F_3	50	20	30	7
16	T_4F_4	50	10	40	7
17	T_5F_1	50	40	10	10
18	T_5F_2	50	30	20	10
19	T_5F_3	50	20	30	10
20	T_5F_4	50	10	40	10
21	T_6F_1	50	40	10	15
22	T_6F_2	50	30	20	15
23	T_6F_3	50	20	30	15
24	T_6F_4	50	10	40	15
25	Control	100	0	0	0

Hardness of Extrudates

Mechanical properties of the extrudates were determined by a three-point breaking test (Zasypkin and Lee, 1998) using a TA – XT2 texture analyzer (Stable Micro Systems Ltd., Godalming, UK) equipped with a 50 Kg load cell. Extrudates of 35 mm long were placed on two rounded stands 30 mm apart. A third rounded crosshead was used to exert force in the middle of the bridge. The cross head was set to move down at 5mm/min until breaking occurred. The hardness was determined as the breaking force (N). Twenty measurements were made on each product and the average value was used.

Bulk Density

Bulk density of extrudates is important in relation to their ability to float or sink when poured into water and their packaging requirement. It will be calculated by measuring the actual dimensions of the extrudates. The diameter and length of twenty pieces of randomly selected extrudate samples will be measured using Vernier caliper. The bulk density will be then calculated using the following formula, assuming a cylindrical shape of extrudate.

$\rho_b = 4W/ \Pi d^2 l$

Where, ρ_b = Bulk density (g/cm^3),

W= Weight of extrudate (g),

d^2 = Diameter of extrudates (cm) and

l = Length of extrudate (cm)

Results

This chapter deals with the results obtained from the present investigation. The extrudates were prepared by using Twin Screw Extruder at three different barrel temperatures 130^{0}C, 150^{0}C and 180^{0}C with screw speed 275 rpm and die diameter 5 mm. It was found that the extrudates prepared at 130^{0}C at screw speed of 275 rpm and 5 mm die diameter has better acceptance as compared to other two temperature i.e.150^{0}C and 180^{0}C. Hence in this study the extrudates for all treatments the temperature 130^{0}C is kept constant for all flour combinations.

Moisture content of Extrudates

The moisture content of the extrudates prepared in different treatment was determined by Air oven method. The details are given in fig.2. The maximum moisture content (12.89 %) was found in treatment T1 with flour combination F4. The lowest moisture content was found in Treatment T4 (7% kokum rind powder) for all the flour combination, where as the 10.44 % moisture content was found in the control treatment (100% corn based flour).

Expansion Ratio

The measured expansion ratio of the extrudates at different flour combination varied between 1.91 and 2.76. Fig 3 shows the trend of variation in the expansion ratio of for different treatments and for all flour combination. The expansion ratio was highest 2.78 for treatment T4 (7 % kokum rind powder) with flour combination F1. There was no significant difference in expansion ratio for treatment T3 and T4 for all flour combination. The expansion ratio control treatment was 1.91.It was found that for all the treatment of blending of kokum rind powder the expansion ratio was higher than the control treatment. (100% corn flour).

Bulk Density

Bulk density of extrudates is important parameter in the production of expanded food products and also in relation to their ability to float or sink when poured into water and their packaging requirement. Bulk density, which considers expansion in all directions, ranged from 101.75 to 343.25 kg/m^3 in the present investigation for all treatment combination, where as the bulk density of corn extrudates was lowest 99.66 kg/m^3.

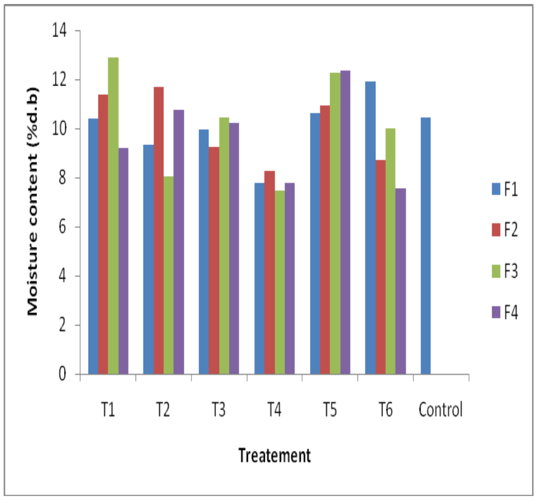

Fig. 2: Effect of kokum rind powder on moisture content of extrudates.

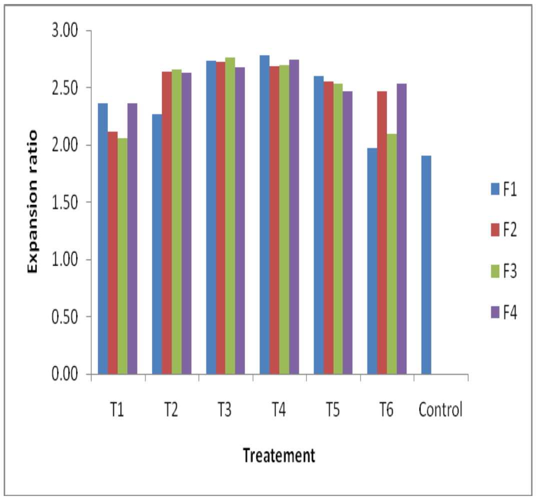

Fig. 3: Effect of kokum rind powder on expansion ratio of extrudates.

The variation in bulk density for different treatment is given fig.4. As the kokum rind powder level increases, the bulk density increases except for treatment T2 (i.e.3% kokum rind powder level. The bulk density for Treatment T6 and flour combination F1 is highest. However bulk density for all flour combination of and kokum rind powder treatment is higher than the control.

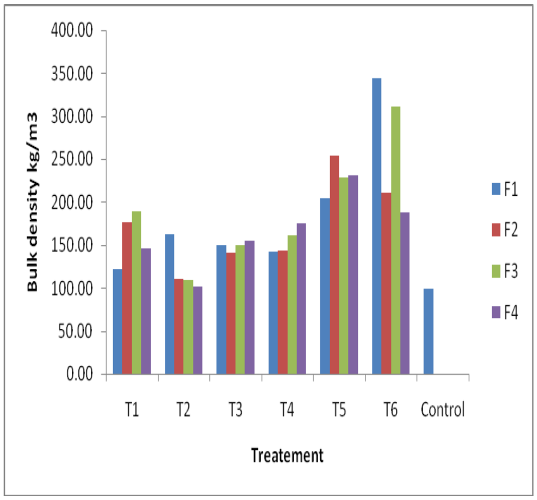

Fig. 4: Effect of kokum rind powder on Bulk density of extrudates.

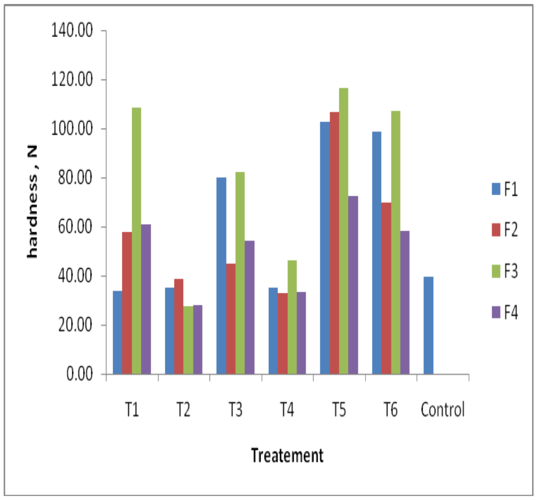

Fig. 5: Effect of kokum rind powder on Hardness of extrudates.

Hardness

The harness of extrudates prepared for different flour combinations are given in fig.5.The flour combination F3 of corn: rice: horse gram i.e.50: 20:30 has shown comparatively highest hardness than other flour levels. The treatment T5 and T6 (10 % and 15 % kokum rind powder) has observed higher hardness that other treatment levels. The lowest hardness 39.44 N was observed for the corn extrudates. The extrudates prepared by using 3% and 7 % kokum rind powder (T2 and T4) has also shows comparatively lower hardness. However the extrudates prepared at 7 % kokum rind powder has more acceptability as compared to other treatments.

Conclusion

The extrudates could be developed from cereal and legume based composite flour and blended with kokum rind powder by using twin screw extruder. It is concluded from this present study that by using twin screw extruder at 130^{0}C barrel temperature, 275 screw speed and with 5 mm die diameter using corn as a base material, rice and horse gram and blended with 7 % kokum rind powder good quality extrudates are developed.

Referances

Altan A., L. Kathryn, McCarthy and M. Medeni. 2008-a. Twin screw extrusion of barley-grape pomace blends: Extrudate characteristics and determination of optimum processing condition. *Journal of Food Engineering*. 89:24-32.

Bhattacharaya P., U. Ghosh, H. Gangopadhyay and U. Raychaudhuri. 2005. Physico-chemical characteristics of extruded snacks prepared from rice, corn and taro by twin screw extrusion. Journal of Scientific & Industrial Research. 65: 165-168.

Bhattacharyya S., H. Das and A. N. Bose. 1993. Effect of extrusion process variables on microstructure of blends of minced fish and wheat flour. Journal of Food Science and Technology. 21 (1): 22-28.

Borhade, V.P., S.S. Kadam and D.K. Salunkhe. 1984. Changes in phytate phosphorus and minerals during germination and cooking of horse gram and moth bean. Plant Food for Human Nutrition 34(2):151-157.

Bruntha D. P., V. Rajendran, S. Sathyaseelan, R. Bhat and B. Venkatesan. 2012. Enhancement of nutritional value of finger millet-based food (Indian dosa) by co-fermentation with horse gram flour. International Journal of Food Sciences and Nutrition 63(1):5-15.

Camire ME, Camire A, Krumhar K (1990) Chemical and nutritional changes in foods during extrusion. Crit Rev Food Sci Nutr 29: 35-57.

Caravalho.W P and J.R.Mitchell. 2000. Effect of sugar on extrusion of maize grits and wheat flour. International Journal of Food Science and Technology.35:569-576.

Da Silva MC, De Carvalho CWP, Andrade CT (2009) The effects of water and sucrose contents on the physicochemical properties of non-directly expanded rice flour extrudates Ciênc Tecnol Aliment 29: 3

Deshpande H. W. and A. Poshadri. 2011. Physical properties and sensory characteristics of extruded snacks prepared from Foxtail millet based composite flours. International Food Research Journal.18: 59-64.

Faller J. Y., B. P. Klein and J. F. Faller. 1999. Acceptability of extruded corn snacks as affected by inclusion of soy protein. Journal of Food Science. 64(1): 185-188.

Guzman L.B., T. C. Lee and C. O. Chichester. 1992. Lipid binding during extrusion cooking. In: Food Extrusion Science Technology. Dekker Press, New York, USA.

Iwe M.O. 1998. Effects of extrusion cooking on functional properties of mixtures of full-fat soy and sweet potato. Plant Foods for Human Nutrition. 53: 37-46.

Iwe MO, Van Zuilichem DJ, Ngoddy PO (2001) Extrusion cooking of blends of soy flour and sweet potato flour on specific mechanical energy (sme), extrudate temperature and torque. J Food Process Pres 25: 251-266.

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

Kohda Y., A. Takayoshi and Sutrisno. Effects of feed moisture content and process temperature on the product properties and processing characteristics of cassava extrusion. Science Bulletin of the College of Agriculture University of Ryukyu.36:89-97.

Laike K., W., W. Solomon, B. Geremew and Y. Senayit. 2010. Effect of extrusion operating conditions on the physical and sensory properties of tef (Eragrostis tef [Zucc.] Trotter) flour extrudates. Eithppian Journal of Agricultural Science and Technology. (1): 27-38.

Laureys C. 1999. A natural choice for texture in: “Rice derivatives”, Sunrice research organization, P. Williams, Y. pan and V. Poulson Eds. p. 2.

Lazou A, Krokida M (2010) Structural and textural characterization of corn–lentil extruded snacks. J Food Engg 100:392-408.

Milain-Carrillo J, Reyes-Moreno C, Armienta-Rodelo E, Carábez-Trejo A, Mora-Escobedo R (2000). Physicochemical and nutritional characteristics of extruded flours from fresh and hardened chickpeas (Cicer arietinum L). Lebensm Wiss Technol 33:117-123

Murekatete N., H. Fie and I. Claver. 2010. Characterization of Ready-to-Eat Composite Porridge Flours made by Soy-Maize-Sorghum-Wheat Extrusion Cooking Process. Pakistan Journal of Nutrition. 9(2):171-178.

Plahar W. A., B. O. Okezie and C. K. Gyato. 2003. Development of a high protein weaning food by extrusion cooking using peanuts, maize and soybeans. Plant Foods for Human Nutrition. 58(3): 1-12.

Priya witkul W., L. R. Beutch, R. D. Philips and A. V. A. Resurreccion. 1995. Modeling the effects of peanut flour, feed moisture and extrusion temperature on physical properties of an extruded snack product. International Journal of Food Science. 30: 37-44.

Riaz M. N. 2000. Extruders in food applications. 1st ed., Lancaster, PA, Technomic Publishing Company, Inc.

Rodríguez-Miranda J, Ruiz-López II, Herman-Lara E, Martínez-Sánchez CE, Delgado-Licon E, Vivar-Vera MA (2010). Development of extruded snacks using taro (Colocasia esculenta) and nixtamalized maize (Zea mays) flour blends. Lebensm-Wiss Technol Available Online 8 July 2010.

Ruiz-Ruiz J, Martínez-Ayala A, Drago S, González R, Betancur-Ancona D, Chel-Guerrero L (2008). Extrusion of a hard-to-cook bean (Phaseolus vulgaris L.) and quality protein maize (Zea mays L.) flour blend. Lebensm Wiss Technol 41:1799-1807.

Santosa B. A., S. Sudaryano and S. Widowati. 2008. Characteristics of extrudate from four varieties of corn with aquadest addition. Indonesian journal of Agriculture. 1(2):85-94.

Sharma S., A. K. Saxena and V. K. Saxena. 2002. Nutritional quality of evaluation of selected improved maize genotypes of Punjab. The Indian Journal of Nutrition and Dietetics. 39: 194-196.

Singh B, Sekhon KS, Singh N (2007b) Effects of moisture, temperature and level of pea grits on extrusion behaviour and product characteristics of rice. Food Chem 100:198-202.

Sudha, N., J. Mushtari Begum, K.G. Shambulingappa, and C.K. Bapu.1995. Nutrients and some antinutrients in horse gram (Macrotyloma uniflorum L.verdc.). Journal of Food Chemistry 55(3):58-62

Upadhyay A, Sharma H and Sarkar B (2010) Optimization of carrot pomace powder incorporation on extruded product quality by response surface methodology. J Food Qual 33: 350–369.

Verardo V, Ferioli F, Riciputi Y, Iafelice G, Marconi E, Caboni MF (2009) Evaluation of lipid oxidation in spaghetti pasta enriched with long chain n−3 polyunsaturated fatty acids under different storage conditions. Food Chem 114:472-477.

Zhou Z., K. Robards, S. Helliwell and C. Blanchard. 2002. Composition and functional properties of rice. International Journal of Food Science and Technology. 37: 849–868.