Study of extrusion behaviour and porridge making characteristics of wheat and guava blends

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Abstract Extrusion cooking studies were carried out with a view to develop an instant porridge from wheat grits and guava pulp at different levels from 10 to 50 %. The mixtures were dried to bring down the moisture content to 12, 15 or 18 % and processed using twin screw extruder. The properties of extrudates (expansion ratio and density) and porridge (water absorption index, water solubility index and sensory quality) were studied. Increase in feed moisture content and guava pulp level resulted in the decrease in expansion ratio and increase in density of the extrudates. Water absorption index (WAI) increased and water solubility index (WSI) decreased with increase in feed moisture content. With increase in level of pulp, WAI decreased and WSI increased. Highly acceptable porridge was obtained at 15 % feed moisture content and 20 and 30 % guava pulp. To the samples with selected feed moisture and pulp levels, sugar was added at 20, 25 and 30 % levels to prepare the final product. Sugar level of 30 % was found out to be most acceptable. Fruit porridge stored in LDPE and aluminum laminate pouches at ambient temperature remained acceptable upto 6 months.

Keywords Extrusion · Wheat porridge · Water solubility index · Water absorption index · Expansion ratio

Wheat (*Triticum aestivum*) is an important grain crop having predominant place among cereals. In India, it ranks second after rice. In most of the Indian states including Punjab, wheat is the staple food. Green revolution in the country during the

sixties and seventies resulted in a manifold increase in wheat production. In the last two decades also wheat production witnessed a spectacular increase from 44.5 million tonnes in 1987–1988 to 88.31 million tonnes in 2011–2012 (Sally 2012). Production of wheat in Punjab during the year 2011–2012 was 15.53 million tonnes and it contributed more than 130 lakh tonnes to the central food grains pool. Wheat is the leading source of calories and protein for human nutrition and it provides more than 20 % of calories in our diets.

Porridge is one of the important processed foods made from grains. Porridge was a traditional food in most of Northern Europe but its growing popularity has made it truly a healthy food worldwide. It was primarily a savory dish, with a variety of meats, root crops, vegetables, and herbs added for flavour. In many modern cultures, porridge is eaten as a breakfast dish and made by boiling oats or sometimes another cereal in water, milk, or both. In addition to oats, cereal meals used for porridge include rice, wheat, barley and corn.

Traditionally in India wheat porridge (*dalia*) is made out of cracked wheat. It is cooked in milk or water, and is eaten with salt or sugar added. But with development of food processing technologies, some manufacturers of breakfast cereals sell “ready-made” versions of porridge. Acceptability and nutritional attributes are frequently enhanced by added ingredients and sophisticated processing and packaging (Fast 1987). Extrusion cooking is processing technology, which is being adopted for processing ready-to-eat (RTE) breakfast cereals and many other products. The advantages of extrusion include high throughput, energy efficiency, thermal control, minimum processing time and ability to incorporate a variety of ingredients into the final product (Eastman et al. 2001).

Development of products from the combination of cereals with fruits and vegetables is being experimented in number of products. Cereals are good source of carbohydrates and proteins and fruits or vegetables could supplement the vitamins, antioxidants, fiber and phytochemicals in the products.

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Fruit-flavoured cereal pieces have long been common ingredients in breakfast cereal offerings, but today more and more real fruit pieces are vying for space in products. Call them value-added or convenience foods, these fruit and cereal combinations are one of the newest trends in ready-to-eat breakfast and hot cereals. In this context, Guava (*Psidium guajava* L.), now being recognized as “super food” is getting very much attention in the agro-food business due to the attractive characteristics of the fruit, such as excellent digestive and nutritive value, pleasant flavor, high palatability and availability in abundance at moderate price. The utilization of guava for preparation of breakfast foods has not been explored much. Porridge can be used as good vehicle for supplementation of guava fruit to add value, to improve nutritional composition and enhance appeal. Hence, the present investigation was proposed to introduce a new instant breakfast cereal product i.e. wheat porridge incorporating guava fruit by using extrusion technology.

Materials and methods

Raw materials Wheat (variety PBW-343) was procured from Department of Plant Breeding and Genetics, PAU, Ludhiana, India. It was thoroughly cleaned and stored in plastic bins for subsequent investigation. Guava (variety L-49, being important variety of North India), ground cane sugar and guava fruit emulsion (K.K. Industries, Delhi) were procured from the local market. Low density polyethylene (40 microns) and aluminium laminate (polyethylene/aluminium foil/polyethylene- 40 microns) were used for packaging of porridge. Packaging materials were purchased from local market.

Preparation of blends Cleaned wheat was milled to grits in a laboratory mill (Model-3303 Perten, Sweden) to pass through 850 microns sieve. Wheat grit had 10.26 % moisture, 11.9 % protein, 1.46 % fat, 1.18 % crude fiber, 1.58 % ash and 69.8 % carbohydrates. Guava pulp was obtained by crushing the fruit pieces in the mixer (Kenstar Karishma, Videocon Industries Ltd. India) and was mixed with wheat grits at a level of 10, 20, 30, 40 and 50 g/100 g of wheat grits (based upon the preliminary trials). The samples were dried at 50 °C to obtain a final moisture content of 12, 15 and 18 % (on wet basis).

Extrusion The samples were extruded using a Clextral BC-21 twin screw, co-rotating, intermeshing, self-wiping extruder (Clextral, Firminy, France) having screw diameter 25 mm and L/D ratio 16:1 at a temperature of 50, 100, 150 and 160 °C for first, second, third and fourth zone respectively. The screw speed was kept constant at 400 rpm. The diameter of die opening was 5 mm. The screw configuration is shown in Table 1 and Fig. 1.

Properties of extrudates and porridge Functional and sensory quality of extrudates and porridge was used as criteria to select the best levels of feed moisture content and guava pulp.

Expansion ratio was determined by taking the diameter of 10 extrudates with the help of vernier calliper (Absolute Digimatic Caliper, Series-500, Innox, Japan), averaged and divided by the diameter of the die nozzle of extruder (Rayas-Duarte et al. 1998). The Density of the extrudates was calculated as per mass per unit volume, using the expression:

$$\text{Density (g/cm}^3\text{)} = \text{mass}/\pi r^2 l (\text{cm}^3)$$

Water absorption index (WAI) and water solubility index (WSI) of the product were determined by method outlined by Anderson et al. (1969). 200 ml of hot milk was added to 20 g ground porridge and it was served hot. The samples were evaluated for Overall acceptability scores through a panel of semi-trained judges using nine point hedonic scale.

Selection of samples for further study Based on the results obtained from the above conducted tests, porridge extruded at 15 % moisture content with 20 and 30 % guava fruit pulps were selected for further study. Sugar in different levels (20, 25 and 30 %) was incorporated in above selected samples. Wheat grits, guava pulp and sugar were mixed together. The samples were kept at 50 °C to bring the moisture content to 15 %. The samples were extruded using the earlier mentioned conditions using a die with four openings having 1.5 mm diameter of each opening. A two bladed die face cutter, run at a speed of 15 rpm, was used to cut the extrudates so that porridge like granulation was obtained. Guava fruit emulsion was sprayed at the exit of die @1.0 % of the finished product.

Sensory quality 200 ml of hot milk was mixed with 10–20 g sugar (optional) and 20 g of porridge was added to it, mixed and served hot. The organoleptic evaluation of the samples was conducted by a panel of ten semi-trained judges using the 9- point Hedonic Rating Scale (Amerine et al 1965). Samples with 30 % sugar were awarded higher score, so these samples were subjected to further analysis.

Chemical characteristics of porridge Moisture, protein, fat, fibre, sugars and starch were determined using AACC (2000) methods.

Storage studies Selected porridge samples prepared were packed in low density polyethylene (LDPE) and aluminium laminate pouches and heat sealed. Samples were stored under ambient temperature (15–34 °C) conditions for shelf life studies by measuring moisture gain at regular intervals of 30 days over a period of 6 months. Relative humidity at room temperature during this period was 70 %.

Table 1 Screw configuration in different sections of the extruder (from hopper to die)

Screw section	1	2	3	4	5	6	7	8	9	10
Screw element	BAGUE	C2F	C2F	C2F	C2F	C2F	INO 0	C1F	CF1C	C1F
Length (mm)	20	50	50	50	50	50	5	50	25	50
Pitch (mm)	–	50	33.33	25	25	16.66	–	16.66	12.5	12.5

Statistical analysis of data Values were mean of three replicate. Data collected was subjected to statistical analysis with the help of analysis of variance technique (Steel and Torrie 1960). The least significant difference (LSD) was used as the test for significance.

Results and discussion

Functional and sensory properties of extrudates

Expansion ratio The expansion ratio and bulk density of extrudates describe the degree of puffing undergone by the material as it exits the extruder. Sectional expansion index considers expansion only in the direction perpendicular to extrudate flow, while bulk density considers expansion in all directions (Falcone and Phillips 1988). Data with respect to the effect of moisture content and level of guava fruit pulp is presented in Table 2.

The measured expansion ratio of wheat grits and guava pulp blend extrudates varied between 2.31 and 3.79. Mean values of expansion ratio shows that the feed moisture content of 12 % resulted in higher expansion ratio (3.38) followed by 15 % (3.32) and 18 % (2.68) moisture content. With increase in guava pulp level, a decreasing trend of expansion ratio was observed. The feed moisture content of 12 and 15 % and fruit pulp level of 0–20 % resulted into the higher expansion ratio. Mean values showed significant decrease in expansion beyond 15 % moisture content. Addition of 30 % or more of guava pulp resulted in significantly lower expansion.

Several researchers have demonstrated that the expansion ratio of extruded cereals depends on the degree of starch gelatinization (Case et al. 1992; Chinnaswamy and Hanna 1988). Increasing level of guava pulp resulted in decrease in expansion ratio of extrudates. This may be attributed to dilution effect of fruit pulp on starch. Also this effect may be attributed to the high fibre content, which competes for the free water found in the matrix, lowering its expansion capabilities. Similar finding of lowering expansion ratio of

extruded biscuits by incorporation of extruded orange pulp containing higher fiber was reported by Larrea et al. (2005).

Density Bulk density is a very important parameter in the production of expanded and formed food products. Bulk density has been linked with the expansion ratio in describing the degree of puffing in extrudates (Asare et al. 2004). Data with respect to the effect of moisture content and level of guava fruit pulp on density is presented in Table 2. Density, which considers expansion in all directions, ranged from 0.12 to 0.31 g/cc in case of guava porridge. The mean values of density showed that feed moisture content of 18 % resulted in significantly higher density (0.25 g/cc) and there was a non significant difference among values of 12 and 15 % feed moisture content. Increase in the level of fruit pulp showed an increasing trend of density. Compared with the control, the level of guava fruit pulp had a significant effect on the mean values for density beyond 20 % and 40 % pulp level respectively. The highest density was recorded at 50 % incorporation of fruit pulp.

A high bulk density is associated with a low expansion index (Rayas-Duarte et al. 1998; Suknark et al. 1997). Samples extruded at 15 % feed moisture content indicated a comparatively low density and high expansion ratio. At low feed moisture content, heat energy directly increases the product temperature. As the product temperature increase, the materials are more fully cooked and become more plastic. This condition and high flashing moisture in the die caused the product to expand more, reduced its bulk density and product moisture content (Kohda et al. 1989). Ding et al. (2006) reported that increased feed moisture leads to a sharp increase in extrudate density. High feed moisture resulted in a rubbery texture with relatively high density. Increase in bulk density with increase in level of fruit pulp may be due to increasing fibre content of feed material. This was because the presence of fibre particles tended to rupture the cell walls before the gas bubbles had expanded to their full potential (Lue et al. 1991).

Water absorption index (WAI) Water absorption has been generally attributed to the dispersion of starch in excess water, and

Fig. 1 Screw profile

Table 2 Effect of feed moisture content and level of guava pulp on functional and sensory quality of wheat extrudates and wheat porridge

Parameter	Moisture (%)	Level of guava pulp (%)						Mean $\pm$ SD
		0	10	20	30	40	50	
Expansion ratio for extrudate	12	3.79 $\pm$ 0.13	3.55 $\pm$ 0.11	3.38 $\pm$ 0.18	3.44 $\pm$ 0.11	3.14 $\pm$ 0.14	2.97 $\pm$ 0.11	3.38 $\pm$ 0.13
	15	3.67 $\pm$ 0.11	3.52 $\pm$ 0.21	3.67 $\pm$ 0.13	3.28 $\pm$ 0.17	3.10 $\pm$ 0.26	2.69 $\pm$ 0.19	3.32 $\pm$ 0.18
	18	3.16 $\pm$ 0.08	2.99 $\pm$ 0.09	2.50 $\pm$ 0.06	2.31 $\pm$ 0.08	2.51 $\pm$ 0.09	2.59 $\pm$ 0.03	2.68 $\pm$ 0.07
	Mean $\pm$ SD	3.54 $\pm$ 0.11	3.35 $\pm$ 0.14	3.18 $\pm$ 0.12	3.01 $\pm$ 0.12	2.92 $\pm$ 0.16	2.75 $\pm$ 0.11	3.13 $\pm$ 0.13
	LSD($p \leq 0.05$)	0.40						
Density (g/cc) of extrudate	12	0.12 $\pm$ 0.02	0.15 $\pm$ 0.13	0.16 $\pm$ 0.03	0.14 $\pm$ 0.01	0.15 $\pm$ 0.11	0.18 $\pm$ 0.01	0.15 $\pm$ 0.05
	15	0.13 $\pm$ 0.11	0.18 $\pm$ 0.18	0.17 $\pm$ 0.08	0.21 $\pm$ 0.07	0.22 $\pm$ 0.06	0.25 $\pm$ 0.01	0.19 $\pm$ 0.08
	18	0.19 $\pm$ 0.08	0.22 $\pm$ 0.09	0.23 $\pm$ 0.01	0.27 $\pm$ 0.01	0.31 $\pm$ 0.10	0.30 $\pm$ 0.04	0.25 $\pm$ 0.05
	Mean $\pm$ SD	0.15 $\pm$ 0.07	0.18 $\pm$ 0.13	0.19 $\pm$ 0.04	0.21 $\pm$ 0.03	0.23 $\pm$ 0.09	0.24 $\pm$ 0.02	0.20 $\pm$ 0.06
	LSD($p \leq 0.05$)	0.09						
Water absorption index (WAI, g/g) of porridge	12	5.01 $\pm$ 0.08	5.03 $\pm$ 0.05	4.92 $\pm$ 0.04	4.95 $\pm$ 0.07	4.93 $\pm$ 0.12	4.71 $\pm$ 0.04	4.93 $\pm$ 0.06
	15	6.35 $\pm$ 0.12	6.40 $\pm$ 0.18	6.10 $\pm$ 0.14	5.91 $\pm$ 0.11	6.02 $\pm$ 0.10	5.82 $\pm$ 0.12	6.10 $\pm$ 0.13
	18	6.48 $\pm$ 0.10	6.28 $\pm$ 0.13	6.17 $\pm$ 0.11	5.99 $\pm$ 0.17	6.09 $\pm$ 0.14	5.73 $\pm$ 0.11	6.12 $\pm$ 0.13
	Mean $\pm$ SD	5.95 $\pm$ 0.09	5.90 $\pm$ 0.11	5.73 $\pm$ 0.11	5.62 $\pm$ 0.18	5.68 $\pm$ 0.15	5.42 $\pm$ 0.13	5.72 $\pm$ 0.13
	LSD($p \leq 0.05$)	0.22						
Water solubility index (WSI, %db) of porridge	12	21.92 $\pm$ 0.26	22.38 $\pm$ 0.21	22.34 $\pm$ 0.19	22.80 $\pm$ 0.21	22.98 $\pm$ 0.18	22.99 $\pm$ 0.14	22.57 $\pm$ 0.20
	15	19.05 $\pm$ 0.29	20.58 $\pm$ 0.17	21.48 $\pm$ 0.19	21.62 $\pm$ 0.17	21.88 $\pm$ 0.23	22.42 $\pm$ 0.21	21.17 $\pm$ 0.21
	18	18.41 $\pm$ 0.23	19.24 $\pm$ 0.19	19.16 $\pm$ 0.12	20.58 $\pm$ 0.19	19.22 $\pm$ 0.13	19.64 $\pm$ 0.17	19.38 $\pm$ 0.17
	Mean $\pm$ SD	19.79 $\pm$ 0.26	20.73 $\pm$ 0.19	20.99 $\pm$ 0.17	21.67 $\pm$ 0.19	21.36 $\pm$ 0.18	21.68 $\pm$ 0.17	21.04 $\pm$ 0.19
	LSD($p \leq 0.05$)	1.18						
Overall sensory acceptability (score out of 9) of porridge ($n=10$)	12	6.08 $\pm$ 0.06	6.37 $\pm$ 0.08	7.36 $\pm$ 0.11	7.23 $\pm$ 0.11	7.15 $\pm$ 0.09	6.80 $\pm$ 0.09	6.83 $\pm$ 0.09
	15	7.10 $\pm$ 0.10	7.34 $\pm$ 0.10	7.62 $\pm$ 0.13	7.67 $\pm$ 0.13	7.25 $\pm$ 0.11	6.29 $\pm$ 0.09	7.38 $\pm$ 0.11
	18	6.66 $\pm$ 0.07	6.03 $\pm$ 0.05	7.23 $\pm$ 0.10	6.85 $\pm$ 0.07	6.82 $\pm$ 0.07	6.11 $\pm$ 0.04	6.62 $\pm$ 0.06
	Mean $\pm$ SD	6.61 $\pm$ 0.07	6.58 $\pm$ 0.08	7.40 $\pm$ 0.11	7.25 $\pm$ 0.10	7.07 $\pm$ 0.10	6.73 $\pm$ 0.07	6.94 $\pm$ 0.09
	LSD($p \leq 0.05$)	0.26						

the dispersion is increased by the degree of starch damaged due to gelatinization and extrusion-induced fragmentation, that is, molecular weight reduction of amylase and amylopectin molecules (Rayas-Duarte et al. 1998). The processing conditions (i.e. feed moisture content and level of guava pulp) affected WAI of extrudates. The values of WAI ranged between 4.71 and 6.48 g/g (Table 2).

As the feed moisture content increased from 12 to 18 %, the mean values for water absorption index showed an increasing trend. The water absorption index tended to be higher with higher starch content. Increase in level of guava pulp showed a decreasing trend of water absorption index.

WAI is a gelatinization index and it is generally agreed that feed moisture and barrel temperature exert greatest effect on the extrudate by promoting gelatinization (Ding et al. 2005). At high moisture content, the viscosity of the starch would be low, allowing for extensive internal mixing and uniform heating which would account for enhanced starch gelatinization (Lawton and Handerson 1972) which may lead to increased water absorption. Similar effects of increasing

moisture content on WAI have been reported earlier for rice based extrudates (Ding et al. 2005) and extrusion of rice with pea grit (Singh et al. 2007). WAI decreased considerably as the percentage of fruit pulp increased. This may be attributed to relative decrease in starch content with addition of pulp and competition of absorption of water between pulp and available starch. This result is in agreement with those of Artz et al. (1990). They reported a decrease in water holding capacity when the ratio of fiber/corn starch increased in extrusion of corn fiber and corn starch blend.

Water solubility index (WSI) Water solubility index, often used as an indicator of degradation of molecular components (Kirby et al. 1988), measures the degree of starch conversion during extrusion which is the amount of soluble polysaccharide released from the starch component after extrusion (Ding et al. 2005). WSI values for the extrudates ranged from between 18.41 and 22.99 % (Table 2). Mean values of water solubility index showed that the feed moisture content had significant effect on the WSI with 12 % resulted into highest

Table 3 Effect of sugar level on sensory quality (score out of 9) of guava incorporated porridge made from wheat

Sugar level (%)	Control	Level of guava pulp (%)		Mean $\pm$ SD
		20	30	
20	6.43 $\pm$ 0.09	6.36 $\pm$ 0.03	6.63 $\pm$ 0.09	6.47 $\pm$ 0.07
25	6.68 $\pm$ 0.06	7.02 $\pm$ 0.07	7.07 $\pm$ 0.10	6.92 $\pm$ 0.08
30	7.24 $\pm$ 0.05	7.13 $\pm$ 0.08	6.75 $\pm$ 0.07	7.04 $\pm$ 0.07
Mean $\pm$ SD	6.78 $\pm$ 0.07	6.84 $\pm$ 0.06	6.82 $\pm$ 0.08	6.81 $\pm$ 0.07
LSD ($p \leq 0.05$)	0.28			
($n=10$)				

water solubility index followed by 15 % and 18 % moisture content. Increase in level of fruit pulp showed an increasing trend of water solubility index and compared to control a significant increase was observed beyond 10 % guava pulp. Higher values for water solubility index were recorded at feed moisture content of 12 % and level of fruit pulp 40–50 %.

Similar effects have been reported in literature for rice-based extrudates (Ding et al. 2005) and maize-finger extrudates (Onyango et al. 2004). It was suggested that increasing WSI is caused by greater shear degradation of starch during extrusion at low moisture conditions. Jean et al. (1996) reported that extrudates at low feed moisture content have higher compressive resistance and cause solubility changes in the starch. The solubility increase in extrudates means the starch granule increases the fragmentation ratio at low feed moisture during extrusion of corn meal (Gomez and Aguilera 1983; Wen et al. 1990).

WSI increased as a function of pulp content. WSI is a parameter that reflects the degradation suffered by the components of the fiber (Larrea et al. 2005).

Overall acceptability Overall acceptability of guava pulp incorporated wheat porridge is presented in Table 2. The mean scores of sensory evaluation showed that all products with fruit pulp were within the acceptable range. A statistically significant difference was observed for mean values of overall acceptability. The consumer acceptability for wheat porridge incorporating guava pulp was maximum when the grits were extruded at 15 % moisture content and fruit pulp level of 20

*P- Low density polyethylene

**L- Aluminium laminate

Fig. 2 Effect of storage at ambient conditions on moisture content (%) of porridge packed in low density polyethylene (P) and aluminium laminate (L)

and 30 %. Significantly lower mean value was recorded for fruit pulp level 10 and 50 % as compared 40 % because of lower expansion. If the product expands less, a compact structure appears to be dull and hence it results in low score in sensory.

Effect of sugar level on sensory quality

The effect of sugar level on sensory quality of guava incorporated porridge is given in Table 3. It was observed that with increase in sugar level, overall acceptability increased for each level of guava pulp incorporation. A noticeable increase in the appearance of porridge was observed with increase in level of sugar incorporation.

Significant variations in the organoleptic scores were observed when sugar was incorporated in selected samples (20 and 30 % guava pulp) of porridge at three different levels. Porridge prepared with 30 % sugar was found most acceptable in terms of overall acceptability scores. Hence, it was selected for further analysis and storage studies.

Chemical characteristics of porridge The proximate composition of porridge samples is depicted in Table 4. A glance at proximate composition of porridge reveals that the protein

Table 4 Chemical composition of selected levels of guava incorporated porridge

Sample	Protein (%)	Fat (%)	Crude fibre (%)	Reducing sugars (% glucose)	Non-reducing sugars (% glucose)	Starch (%)
Control	10.15	1.47	1.57	8.41	11.50	58.67
Guava 20 %	9.41	1.09	2.63	7.76	11.56	57.70
Guava 30 %	9.28	0.83	2.53	8.77	12.62	56.62
LSD($p \leq 0.05$)	0.31	0.21	0.27	0.39	0.31	2.19

content ranged from 9.28 to 10.15 %. Porridge containing 20 and 30 % guava pulp showed less protein and fat percentage as compared to control. Porridge with 30 % guava pulp was observed to have lowest fat percentage (0.83 %). Fiber is mostly present in small amounts (<9 %) except in the high fiber breakfast cereals like oat cereal and cereals in which bran is incorporated. Among all, porridge with 20 % guava pulp had highest amount of crude fiber (2.63 %) followed by 30 % (2.53 %) and control (1.57 %). Statistically significant variability was observed in all products with respect to sugars and starch content. Jones et al. (2000) also reported the chemical composition of thirty-six breakfast cereals purchased from different manufacturers and the results reported are in agreement with the present study.

Storage of porridge Significant variations were observed in the moisture content of guava fruit incorporated porridge packed in low density polyethylene (LDPE) and aluminum laminate pouches during storage under ambient temperature conditions (Fig. 2).

The role of packaging material on the storage stability of guava incorporated instant wheat porridge under ambient temperature (15–34 °C) conditions was investigated on the basis of changes in moisture content. Porridge with 30 % guava pulp had higher initial moisture content than 20 %. The moisture content of porridge packed in polyethylene increased from 7.17 to 8.35 % (in case of Control P), 7.24 to 8.49 % (in case of Guava 20 % P) and 7.47 to 8.39 % (in case of Guava 30 % P) as compared to 7.18 to 8.20 % (in case of Control L) 6.84 to 8.33 % (in case of Guava 20 % L) and 6.97 to 8.28 % (in case of Guava 30 % L) for those packed in aluminium laminate at the end of 6 month storage. The increases were considerably higher in polyethylene packed samples than those in aluminium laminate. Visibly, the samples packed in both the packaging materials were not significantly different in color either initially or after storage. Moisture gain by biscuits in different packaging material has been reported by Zabik et al. (1979) and Sathe and Salunkhe (1981). Gupta and Singh (2005) reported that moisture content in different categories of biscuits increased after 60 days of storage at room temperature. Singh et al. (2000) also reported that the moisture contents of samples increased with the time of storage.

Conclusion

It is concluded that wheat and guava blends can be extruded into an acceptable, nutritional and traditional breakfast food (porridge). The guava incorporated instant wheat porridge extruded at 15 % feed moisture content and 20 % guava pulp level with 30 % of sugar was found out to be most acceptable.

Fruit porridge could be stored for 180 days in LDPE under ambient conditions. Thus, it can be stated that fruit incorporated porridge is highly acceptable and could add variety to the breakfast cereal products.

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