

Development and Evaluation of Extruded Weaning Foods

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Abstract:

Extrusion cooking is one of the contemporary food processing technologies applied for preparation of a variety of snacks and supplementary foods. Extruded weaning food was prepared from flour blends made with wheat flour, maize flour, green gram flour and groundnut flour. Material balance method was used in obtaining the proportions of flour that contained 15% protein, above 55% carbohydrate and 7% fat as the constraints (targets). The first batch of material was raw and considered as control. The second and third batch samples were roasted and germinated respectively. These formulations were extruded at 180 rpm screw speed, $100 \pm 10^\circ\text{C}$ die temperature and $15 \pm 2 \text{ kg h}^{-1}$ feed rate in an extruder. Nutrient composition and physical parameters of the formulated food were analyzed. Protein, moisture and energy content of the germinated extruded weaning food were significantly ($p < 0.05$) increased by 5-10% when compared to control and roasted samples. Roasting and germination process decreased 2 – 5% of fat, fibre, ash and carbohydrate content. However improved expansion ratio and length was seen in control sample. The germinated extruded weaning food was better in nutritional composition when compared to other two samples. Therefore extruded weaning food with processed cereal pulse mixture could be formulated to provide essential nutrients required by weanling infants at low cost.

Key words: Extrusion, Weaning foods, Germination, Roasting

Introduction

Weaning is the gradual replacement of breast milk by a good mixed diet (Issac and Koleosho, 2012). Weaning foods are needed to fill the gap between the total nutritional needs of the child and the amount provided by the breast milk and also bridge the change in milk diet to adult food (WHO, 2000). A variety of complementary foods are commercially available with high nutritive value, which are directly used for instant preparation of gruels. However these products are beyond the economic means of most families. So mothers use traditional gruels – water suspensions of maize or sorghum, as complementary foods for infants. These gruels usually have low energy density and poor protein, vitamin and mineral contents (Njongmeta et al, 2003). Thus, protein-energy malnutrition is a common problem among infant and children in the poor socio-economic groups of developing countries.

Traditional complementary food could be improved by combining locally available food that complement each other in such a way that the new pattern of amino acids created by this combination is similar to that recommended for infants (Mensa-Wilmot et al, 2001). Processing technique used for weaning food has been largely fermentation, sprouting/germination, extrusion and less often toasting (Obizoba and Ati, 1981). Fermentation and germination can reduce the high bulk of traditional complementary food by reducing the viscosity of the cereal gruel or porridge (Potter and Hotchloss, 1995).

Extrusion cooking is one of the contemporary food processing technologies applied for preparation of a variety of snacks, specialty and supplementary foods (Riaz, 2006). Extrusion alters the nature of many food constituents, including starches and proteins, by changing their physical, chemical and nutritional properties (Filli and Nkama, 2007).

Destruction of secondary compounds, gelatinisation of starch, increases in soluble dietary fiber and reductions of lipid oxidation generally improve the nutritional quality through extrusion of food and feed mixtures. Changes in proteins and the amino acid profile, carbohydrates, fiber, vitamins, minerals and some non-nutrient components of food and feed mixtures depends on raw material characteristics (e.g., composition and particle size) and processing conditions (Athar et al., 2006). The objective of this research is to determine the effect of two types of processing methods (roasting and germination) on the nutrient composition of extruded weaning foods.

Materials and Methods

Source of raw materials: Wheat, maize, mung bean and groundnut were purchased from the local market, Salem, Tamil Nadu.

Processing of materials: The materials were cleaned to remove dirt and stones, washed, shade dried and divided into three batches. The first batch of material was raw and considered as control. The second and third batch samples were roasted and germinated respectively. Roasting and germination were done by the standard procedures: wheat (Abbey and Mark-Balm, 1988; Tochampa et al, 2004), maize (Housson and Ayenor, 2002; Jowitt, 1977), mungbean (del Rosario and Mubarak, 2005; Chau and Cheung, 1998) and groundnut (Abayomi et al, 2002; Ahmed and Schmidt, 1979).

Composition of weaning food: The flours were blended in a ratio obtained via the material balance method using protein (15%), carbohydrate (above 55%) and fat (7%) as the constraints (targets) (Bureau of Indian Standard, 2007). The formulated product contained 39 % of wheat flour, 34 % of maize flour and

14 % of mung bean flour 13 % of groundnut flour. The four different flours were milled to form a uniform mixture using a blender and sieved with 75 µm mesh.

Extrusion Process: The mixtures were cooked in a twin screw extruder at 130° C with a pressure of 300 psi. The extruder specifications were 10.01 mm for the barrel bore diameter, 12.5 mm for screw length, 9.01 mm for screw diameter and 1.27 mm for opening. The formulations were fed manually into the extruder through the feed hopper, keeping the flights of the screw filled to preclude accumulation of the formulation in the hopper. The hot extrudates were dried for 10 min at 60°C to have better crispness in final extruded product.

Chemical analysis: The samples of the three extruded weaning foods were separately analyzed for proximate composition using the official standard methods. Moisture content of the extrudates was determined by Association of Official Analytical Chemists method (AOAC, 1990). The gross energy values were estimated by multiplying the crude protein, fat and carbohydrate by their at water values of 4, 9 and 4 kcal/g respectively. Protein content was estimated from the crude nitrogen content of the sample determined by the MicroKjeldhal method ($N \times 6.25$) (AOAC, 1990). Fat content of the samples was estimated by Soxhlet method given by American Oil Chemists Society (AOCS, 1981). Carbohydrate was calculated by difference method. Crude fiber content of the samples was determined by the procedure given by Association of Official Analytical Chemists (AOAC, 1990). Total ash was determined using procedure given by Association of Official Analytical Chemists method (AOAC, 1984).

Physical parameters: Physical parameters like length, diameter, density, expansion ratio of the selected extruded products were recorded. Ten samples each of the different

products were taken for measurement and mean of the ten values were recorded. Length and diameter was of the selected extrudates measured using digital vernier calipers in millimeters (Yamayo, Digimatic Caliper). Radial expansion of the selected extrudates at different portions was measured using vernier calipers and an average of 10 measurements was recorded. The expansion ratio was calculated based on the cross sectional diameter of the extrudate and the extruder die. It is expressed by average of diameter of 10 extrudates divided by diameter of the die used (Singh et al., 2000). Bulk density was determined by filling a one liter measuring cylinder with the selected extrudates slightly above the liter mark. The cylinder was tapped 12 times till the products measured up to the liter mark. The weight of the extrudates was taken and it was calculated as Bulk density= Weight (g)/Volume (mL).

Statistical analysis

All statistical analyses were performed using the SPSS version 15.0. For the nutritive composition and physical properties, descriptive statistics (means and standard deviations), and analysis of variance (ANOVA) were used to determine differences among the samples. Duncan's multiple range test ($P < 0.05$) was performed for multiple comparisons.

Results and Discussion

The proximate composition of foods are necessary for life as they act as sources of nutrition to both humans and animals or structural components of large molecules with specific functions as stated in recommended daily allowance (Olapade and Aworh, 2012). The results of proximate composition analysis of the extruded are presented in Table – 1.

Table – 1. Proximate composition of the extruded weaning foods

Proximate Composition	CEWF	REWF	GEWF
Moisture (g)	3.88±0.65 ^a	2.40±0.78 ^b	4.10±1.02 ^c
Energy (Kcal)	370.69±26.35 ^a	390.26±35.12 ^b	411.15±27.25 ^c
Protein (g)	16.12±2.18 ^a	18.03±1.32 ^b	21.24±2.60 ^c
Fat (g)	6.92±1.02 ^a	5.23±0.68 ^b	5.37±0.89 ^c
Carbohydrates (g)	60.23±3.56 ^a	54.45±4.58 ^b	50.02±4.67 ^c
Fibre (g)	2.46±0.48 ^a	2.17±0.36 ^b	2.79±0.47 ^c
Ash (g)	1.85±0.12 ^{NS}	1.88±0.15 ^{NS}	1.82±0.19 ^{NS}

Results are mean ± SD of triplicate analysis. Means in rows with different letters are significantly different (p< 0.05). CEWF – Control Extruded Weaning Food, REWF – Roasted Extruded Weaning Food, GEWF – Germinated Extruded Weaning Food

Moisture is one of the variables that is most influential in modifying the physical properties of extruded products (Avin and others 1992). Moisture content of GEWF was the highest (4.10±1.02) followed by CEWF (3.88±0.65) and RWF (2.40±0.78). Moisture content of all the extrudates varied from 2.40 to 4.10g that is the desired level for extruded snacks in order to maintain the crispness. These values are within the range reported by other investigators (Dansby and Bowell-Benjamin, 2012; Kocherla et al, 2012).The moisture of extrudates was found to be directly related to feed moisture (Falcone and Phillips, 1988). The moisture content of extruded products is complex and may be dependent on factors such as the initial feed moisture content, water binding capacity, and heat of vaporization (Park and others 1993).

Protein content was significantly (p<0.05) higher in GEWF than REWF and CEWF. This observation agreed with other scientific findings that processing techniques such as germination and roasting improved the nutritional quality of the food products, particularly in terms of protein content (Enujiugha et al., 2003; Fasasi, 2009). Higher protein content in GEWF was probably due to change in protein content during malting due to losses of carbohydrates through oxidation during

germination and loss of low molecular weight during soaking and rinsing of grains (Kumari and srivastava, 2000).

Carbohydrate and energy values of the extruded samples ranged between 50.02 ± 4.67 and $60.23 \pm 3.56\%$, 370.69 ± 26.35 and 411.15 ± 27.25 Kcal, respectively. The carbohydrate content of GEWF was lower than CEWF and REWF samples; this is due to the utilization of fat and carbohydrate for biochemical activities of the germinating seeds (Wang et al, 1997). This result is corroborated with Issac and Koleosho (2012) who stated that carbohydrate content and energy content of the raw and germinated extruded samples ranged between 53.95 and 61.73g/100g and 430.15 to 451.27 Kcal, respectively. Though the carbohydrate and fat contents were decreased in processed food the energy value was higher, because the protein content was significantly increased.

Ash content of REWF was higher than CEWF and GEWF. Total ash determines the level of mineral element present in the samples. Roasting caused an increase in ash content due to volatilization of organic content (Obatolu and Cole, 2000). The level of ash in food is an important nutritional indicator for mineral density and also a quality parameter for contamination (Lee et al, 2007). These minerals may include calcium, potassium, phosphorus, iron, sodium, zinc, and magnesium and others at varying amounts. The observed decrease in ash content of GEWF during germination might be due to leaching of minerals during steeping and washing (Inyang and Zakari, 2008).

Fat content of CEWF was significantly ($p < 0.05$) higher than REWF and GEWF. This result is supported by Issac and Koleosho (2012) who indicated that fat content of raw extruded food was $4.63 \pm 0.51\text{g}$ and germinated extruded food was $3.60 \pm 0.01\text{g}$. The observed decrease in fat content during germination might be attributed to the increased activities of the lipolytic enzymes during germination, which hydrolyze fats to fatty acids and glycerol. Fibre content of GEWF was significantly

($p < 0.05$) higher than CEWF and REWF. This result is supported by Issac and Koleosho (2012) who indicated that fibre content of raw sample was $2.28 + 0.02$ g and germinated sample was $3.03 + 0.03$ g.

Physical parameters of the extruded weaning foods

Physical parameters of extruded weaning foods are reported in Table 2. Length of REWF and GEWF significantly decreased when compared to CEWF. Among the extruded products, CEWF showed highest diameter (1.60 mm) when compared to REWF (1.47mm) and GEWF (1.42 mm). Puffing property had been declined due to processing. Similar results are found in extruded products made with sweet whey solids (Onwulata et al. 1998; Onwulata et al., 2010). Nelson (2003) and Berrios (2010) reported that increasing the protein levels will lead to decrease in diameter and expansion ratio of the extrudates.

Table – 2 Physical parameters of the extruded weaning foods

Weaning Foods	Length (mm)	Diameter (mm)	Bulk density (g/ml)	Expansion Ratio
CEWF	4.94±0.64 ^a	1.60±0.30 ^a	0.96±0.02 ^a	3.64±0.13 ^a
REWF	3.88±0.85 ^b	1.47±0.20 ^a	0.94±0.01 ^a	3.03±0.57 ^b
GEWF	3.71±0.54 ^c	1.42±0.23 ^a	0.98±0.02 ^a	2.43±0.27 ^c
F ratio	9.36*	0.09^{NS}	0.77^{NS}	8.02*

Results are mean ± SD of triplicate analysis. Means in rows with different letters are significantly different ($p < 0.05$). CEWF – Control Extruded Weaning Food, REWF – Roasted Extruded Weaning Food, GEWF – Germinated Extruded Weaning Food

Bulk density is a measure of heaviness of the sample (Oladele and Aina, 2007). Increase in bulk density is desirable in that it offers greater packaging advantage as greater quantity maybe packed within constant volume (Molina et al., 1983). However, low bulk density is desirable in the preparation of infant and weaning foods. GEWF had a bulk density of 0.98 g/ml, which was not significantly different of that of CEWF (0.96g/ml) and REWF (0.94 g/ml) as shown in Table 2. Stojceska et al. (2009)

reported that bulk density is highly correlated to the moisture content of the product during extrusion. Onwulata et al (2001), Onwulata et al (2001 b) and Veronica et al (2006) observed that as fibre and protein-rich materials are added to starchy materials, the density of expanded product is increased.

Expansion Ratio (ER) is an important characteristic of extruded products. Extrudates degree of expansion is closely linked to the size, number and distribution of air cells within the material (Suknark et al., 1997). CEWF had significantly ($p < 0.05$) high expansion ratio than REWF and GEWF. This result is similar to the ones shown by Iwe et al (1998) but was different than those reported by Balandran-Quintana et al (1998). During the extrusion process, fat componenets act as lubricants, reducing the degree of cooking and consequently the expansion ratio (Bhattacharya and Hanna, 1988).

Conclusion

Germinated extruded weaning food had higher content of protein and energy than roasted and control extruded weaning foods. The germinated extruded weaning food was better in nutritional composition when compared to other two samples. Therefore extruded weaning food with processed cereal pulse mixture could be formulated to provide essential nutrients required by weanling infants at low cost. Since this study is limited to proximate composition, further biological study on the utilization of the nutrients should be carried out.

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