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Effects of blend and extrusion processing on the quality of extrudates made from milk protein and maize

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Abstract
The quality of extrudates is determined by consumers acceptance based upon the main criteria like colour and appearance along with some other parameters. We studied some of the characteristics of extrudates, colour value, Water Absorption Index (WAI), Water Solubility Index (WSI), expansion ratio of extrudates from different blends of milk protein and maize flour as affected by the composition of blends during extrusion processing. Maize flour was extruded with two different milk protein sources i.e Whey protein concentrate-70 (WPC-70) and rennet casein at different proportion (90:10, 80:20), feed moisture content 12%, feed rpm 340 rpm and extrusion temperature 100°C. Increasing the milk protein content resulted in higher L*, a*, b* value, lower expansion ratio, WAI, WSI in the final extruded product

Keywords: Extrudates, expansion ratio, water absorption index (WAI), water solubility index (WSI)

Introduction
The convenience and accessibility of food lies on the processed foods for most of the consumers. In the recent past years, extrusion processing has become popular due to their HTST processing, which encompasses numerous unit operations including mixing, conveying, cooking, forming and drying. Wider range of food materials can be processed by extrusion processing to develop the newer range of processed products to meet the consumer's demand of novelty. Extrusion processing conditions may govern the alterations in proteins, carbohydrate, dietary fibre, lipids, vitamins, minerals and other bioactive components, in positive or negative manner (Singh *et al.*, 2007) [7]. Normally cereals are preferred raw material for extrusion for expanded snacks but milk protein could also processed with the cereals to enhance the protein content as well as other functional properties of extrudates. Day and Swanson (2013) [3] revealed the scientific literatures on functionality of protein-fortified extrudates and concluded that protein fortification may improve nutritional quality, digestibility, and textural, sensory and physical properties. However, extend of beneficial effects depend on type, amount of protein, composition and moisture in feed, temperature, shear: pressure, residence time and screw configuration. Hence, the objective of this study was taken to determine the effects of extrusion processing on the quality of extrudates made from milk protein and maize combination.

Materials and methods
Sample preparation
Maize grains and Milk protein sources were procured from Karnal Farmer and Modern Dairies Ltd., Karnal, Haryana, India respectively. Level of milk proteins in formulation was adjusted in pre-mix along with maize as shown in Table no.1. Maize flour and milk proteins viz., WPC-70/ Rennet casein were dry-blended by passing through sieve (2 mm) and calculated water was sprayed over it to adjust 12 % moisture in pre-mix. The mixture was again passed through 2 mm size sieve and blended for 15 min to obtain a uniform mixture. The pre-mix was packaged in 1 kg LDPE bag and stored overnight for equilibration of moisture

Table 1: Formulations with different levels of milk protein incorporation into maize flour for composite extrudates

Ingredients (%)	Formulation (treatments)			
	T_1	T_2	T_3	T_4
Maize flour	90	80	90	80
WPC-70	10	20	-	-
Rennet casein	-	-	10	20

Extrusion cooking

A twin screw extruder (Basic Technology Pvt. Ltd., Kolkata, West Bengal, India) was used for the preparation of extrudates. It consists of a feeder and extrusion cylinder having two heating zones. A circular die (4mm diameter) at the exit of the barrel was used for extrusion. The extruder was provided with the water circulation jacket at the exit of the extrusion cylinder for temperature control. The conditioned mixture was fed to feed hopper equipped with screw augers to load materials into the barrel at uniform rate. The extruder screw speed was set at 340 rpm. The temperature of inlet and outlet cooking section was set to 40°C and 100°C, respectively. The plasticized mass was passed through 4 mm die and extruded samples were dried in a tray drier for 30 min at 50°C or till the final moisture reached in the range of 3-5% moisture. The dried samples were collected and stored in the appropriate laminated bags for further analysis.

Chemical analysis

Chemical composition of the extrudates was evaluated by using a standard method (AOAC, 1995) for crude fat, AOAC (2000) micro-Kjeldahl method for protein content, (AOAC, 2000) method for total ash content in the sample.

Physical analysis

Water Solubility Index (WSI) and Water Absorption Index (WAI)

WAI and WSI were determined according to Anderson *et al.*, (1969) method. 2.5 gram of powdered extrudate and 30 mL of water was vigorously mixed in a 50mL centrifuge tube, incubated in a 37°C water bath for 30 min, and then centrifuged at 3500 rpm for 15 min. The supernatant was collected in a pre-weighed aluminum dishes and the residue with respect to the dry weight of extrudate powder used in the test was taken as water solubility index (WSI). The weight ratio of centrifuged precipitate to the dry weight of extrudate powder used in the test was taken as the water absorption index (WAI).

$$\text{WAI} = \frac{\text{WP}}{\text{Wd}};\ \text{WSI} = \frac{\text{Wds x 100}}{\text{Wd}}$$

Solids, W_{ds} = Weight of dissolved solids in supernatant.

Expansion ratio

The ratio of diameter of extrudate and the diameter of die used for preparing extrudate was used to express the radial expansion of extrudate (Fan *et al.,* 1996) [4]. The diameter of extrudate was determined as the mean of 10 random measurements made with vernier calipers. The extrudate expansion ratio was calculated as follows:

$$\text{Expansion ratio} = \frac{\text{Extrudate Diameter}}{\text{Die diameter}}$$

Colour analysis

Hunterlab Colorflex Colormeter (Hunter Associated Laboratory Inc., USA) was used to measure the colour of the extrudate. Data were received through the software in terms of L^* (lightness), ranging from zero (black) to 100 (White), a^* (Redness) +60 (Red) to -60 (Green) and b* (Yellowness) ranging from +60 (Yellow) to -60 (Blue) values of international (CIE) colour system.

Statistical analysis

The data obtained for all the experiments were analysed using Microsoft excel 2010 to get mean and standard error.

Results and discussion

Chemical composition

The chemical composition of extrudates varied among the treatments after extrusion processing. Increasing the milk protein source level in the pre-mix resulted in lower fat content, higher protein content and higher ash content. The highest protein content was found to be 19.39 ± 0.39 and 21.65 ± 0.15 in milk protein- maize based extrudates incorporated with WPC-70 and rennet casein respectively

Table 2: Proximate composition and physical parameters of milk protein – maize based extrudates

Treatments	Physical parameters						Proximate composition		
	WSI (%)	WAI (g g^{-1})	Expansion ratio	L *	a*	b*	Fat (%)	Protein (%)	Ash (%)
T_1	45.5±0.02	6.46±0.05	6.56±0.06	79.55±0.26	1.49±0.08	25.40±0.30	2.15±0.05	12.45±0.19	1.815±0.01
T_2	44.85±0.53	3.31±0.07	3.69±0.03	80.55±0.09	1.44±0.01	23.67±0.03	2.05±0.05	19.39±0.39	1.915±0.01
T_3	44.18±0.37	4.78±0.15	6.38±0.13	79.92±0.08	1.43±0.06	22.89±0.13	2.25±0.05	14.12±0.12	1.7±0.1
T_4	43.73±0.16	2.42±0.1	5.09±0.03	80.63±0.06	1.36±0.07	22.17±0.06	2.15±0.05	21.65±0.15	1.98±0.02

Values are Mean ± S.E (n=3)

Physical characteristics

WAI and WSI

WAI is an indicator for starch gelatinization which is hydrolytic breakdown of starch during extrusion and starch swelling behavior, and WSI is an indicator of starch degradation at molecular level and measures the starch conversion and soluble molecules during extrusion (Ding *et al.,* 2005). With an increase in protein level WAI and WSI decreased in all the treatments. WSI and WAI decreased from 45.5±0.02 - 44.85±0.53 and 6.46±0.05 - 3.31±0.07 while increasing the concentration of WPC-70 level in samples. Similarly, increasing rennet casein incorporation level in composite premix has shown decreasing trend of WSI and WAI from 44.18±0.37 - 43.3±0.16 and 4.78±0.15 – 2.42±0.1respectively. DN Yadav *et al.*,(2014) also observed lower water solubility index and water Absorption index of pearl millet based extrudates supplemented with whey protein. Allen *et al.* (2007) [1] has also observed lower WSI in corn based extrudates incorporated with whey protein.

Expansion ratio

The expansion ratio values of extrudates were in the range of 3.69 ± 0.03 to 6.56 ± 0.06. Addition of WPC-70 in higher concentration to maize flour reduced the expansion ratio from

6.56 to 3.69 in extrudates while higher level of rennet casein incorporation also decreased the expansion in extrudates, but lesser reduction than WPC-70 addition. Addition of milk proteins in formulation might have promoted the interaction between maize flour constituents particularly proteins and lipids with milk proteins resulting decreased starch swelling and thus reduced expansion. The expansion ratio was increased as the maize flour addition increased in oat-corn puff (Liu *et al.,* 2000) [5].

Colour value

Colour is an important physical property for all the food products (Patil *et al.,* 2005) [6]. The mean of L*, a*, b* values of all treatments are presented along with standard error in Table no.2. Increasing the level of milk protein addition resulted in higher lightness of extrudate (L*) whereas yellowness (b*) and redness (a*) decreased by increased level of addition. T_1 and T_3 has shown higher yellowness (b*) and redness (a*) due to higher amount of maize flour and the raw material characteristics. Increasing maize flour content in oat – corn puff resulted in a significant increase in the extrudate yellowness (b* value) due to the carotenoid pigment in the yellow corn flour (Liu *et al.,* 2000) [5].

Conclusion

Addition of milk proteins into maize composite based extrudates improved the nutritional value, especially the protein content of the product. The product developed will create new domestic and export market opportunities for the dairy as well food industry since the product is acceptable with good physico-chemical properties.

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