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Effect of extrusion process on antinutritional factors and protein and starch digestibility of lentil splits

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ABSTRACT

Lentil contains substantial amount of protein, carbohydrate, fiber and other nutrients like folate and iron but their bioavailability and utilization by human is relatively low and less explored, this is due to the presence of various antinutritional factors such as trypsin inhibitor, phytic acid and tannins. The present study was aimed to evaluate the physicochemical and sensory properties of extruded product by using response surface methodology (RSM), effect of different moisture content in raw material and the temperature of extrusion processing on the inactivation of these antinutritional factors in lentil. The attempts were also made to assess in vitro protein and starch digestibility. The die temperature has been varied from 140 to 180 °C with screw speed of 150–250 rpm at constant feed rate 16 rpm (340 g/min) and the feed moisture of the raw material was in the range of 14–22%. It was observed that extrsion was the best method to abolish trypsin inhibitors (99.54%), phytic acid (99.30%) and tannin (98.83%) without altering the protein content. Furthermore, it was also found that the associated thermal treatment was most effective in improving protein and starch digestibility (up to 89% and 96%, respectively) when it was compared with traditional thermal processes.

1. Introduction

Lentil (*Lens culinarisMedikus*) is excellent source of proteins, carbohydrates, dietary fiber and essential minerals (Bishnoi and Khetarpaul, 1994). However, antinutritional factors such as phytic acid, trypsin inhibitors and tannins, which are present in lentil was considered undesirable for obstructing the bioavailability of minerals (Reddy, Sathe, & Salunkhe, 1982) and they compromise the protein digestibility, harming the nutritional value of this food (Sgarbieri and Whitaker, 1982). Therefore, it must be substantial reduction or complete elimination of these antinutrients before they can be safely consumed. The effects of processing on antinutritional factor (which is majorly carried out by extrusion process) vary notably, depending on the techniques and conditions, including time, temperature and moisture content, which in turn can enhance the bioavailability of proteins and minerals (Nestares, Barrionuevo, Urbano, López-Frías, 1999; Nestares, Lopez-Frias, Barrionuevo, & Urbano, 1996). A wide range of processing techniques could improve the protein and starch digestibility of legumes and therefore their utilization (Alonso, Oruae, & Marzo, 1998). However, it is already known and understood that some of the treatments could make physicochemical changes in proteins, starch and other components of legume seeds affecting their overall nutritional properties (De Pilli, Fiore, Giuliani, Derossi, & Severini, 2011; Valle, Quillien, & Gueguen, 1994). In India, and many other countries, lentils are generally processed and consumed in different forms, depending on culture, source and taste preferences. The processing methods include ordinary and pressure cooking or microwave cooking methods are generally used for cooking of lentil, however, there was less reduction of antinutritional factor occurred in this common processing methods (Alonso, Aguirre, & Marzo, 2000).

In recent years, the demand for snacks with improved nutritional and functional properties has been increased. Among these, expanded product has gained preference among both consumers and producers (Ernoult, Moraru, & Kokini, 2002). Extrusion of food is an emerging technology for the food industries to process and produced large number of products of varying size, shape, texture and taste (Kaur, Panday, & Mishra, 2007). Extrusion cooking is used worldwide for the production of expanded snack foods, as there is a huge demand of healthy and nutritious ready-to-eat products from all age groups of consumer. Krokida and Lazou (2010) studied that

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for consumer acceptability structural and textural properties as well as quality of expanded products proven to be more vital. Extrusion conditions such as feed moisture content, extrusion temperature and screw speed were controlled to obtain optimized product quality (Meng, Threinen, Hansen, & Driedger, 2010). Therefore, the aim of this study was to investigate the effects of extrusion processing on the level of antinutritional factor such as trypsin inhibitor, phytic acid, tannins as well as in vitro protein and starch digestibility of lentil extruded product. The present investigations were also carried out to explore the possibility of lentil as a candidate for production of protein rich extruded product and study the effect of feed moisture and extrusion temperature on the antinutritional factors to increases the bioavailability of proteins and starch.

2. Materials and methods

2.1. Materials

Commercial lentil (*Lens culinarisMedik*) was purchased from agriculture produce market committee (APMC), Vashi, Mumbai, India. The lentil was cleaned ground to obtain flour and passed through 60 mesh sieve to obtain uniform particle size. All the chemicals used for the study were of AR grade.

2.2. Methods

2.2.1. Proximate composition

Proximate composition of lentil flour was determined in accordance with the AOAC (1980, 2006) methods. Lentil flour contain 1.03% fat, 23.86% protein, 65.52% carbohydrate, 9.06% moisture and 0.53% ash content and are fairly rich in starch with 54.78%. Starch is the most influential component of lentil seed affecting the structural and functional properties of extrudates. Total fiber contain in lentil flour was 10.84%. The proximate composition, on a dry basis, of lentil flours is depicted in Table 2 as mean values (±standard deviation) of at least three replicates and the mean values are expressed as g per 100 g of sample.

2.2.2. Preparation of sample

Samples were prepared by adding calculated amount of distilled water to obtain the different desired moisture levels (14, 18, and 22%) and allowed to equilibrate for 24 h before extrusion process.

Table 2
Proximate composition of lentil seeds.

Sr.no.	Proximate constituents	Content (g/100 g)
1	Moisture	9.06 ± 0.19
2	Fat	1.03 ± 0.06
3	Protein	23.86 ± 0.11
4	Total carbohydrate	65.52 ± 0.32
5	Ash content	0.53 ± 0.04
6	Starch	54.78 ± 0.12
7	Fiber	10.84 ± 0.06

All the values are Mean ± SD of three individual determinations.

2.2.3. Extrusion process

The lentil flour was extruded in a co-rotating twin screw extruder (KETSE 20/40 Brabender GmbH and Co. KG, Duisburg, Germany) with four independent heating zones. Twin screw extruder has screw diameter of 2 cm and screw length of 40 cm (L/D ratio of 20:1). Screw speed range is up to 900 rpm. The die diameter was 4 mm and feed rate was kept constant at 16 rpm (20.4 kg/hr). The temperature during extrusion was adjusted according to the experimental design by using electric heaters. Extrudates were produced using temperatures in the range of 140–180 °C and three levels of screw speeds (150, 200 and 250 rpm). Temperatures for different zone were Conveying zone (95, 115 and 135 °C), Mixing zone (110, 130 and 150 °C), Cooking zone (125, 145 and 165 °C), High pressure zone (die) (140, 160 and 180 °C). The extrudates were cooled to room temperature, dried in tray dryer at 45 °C for 2 h, packed in polyethylene bags and stored in a desiccator till further analysis.

2.2.4. Experimental design

The response surface methodology was applied using a central composite design (CCD) for three independent variables (Barros-Neto, Scarminio, & Bruns, 2010), namely: the moisture content of the raw material, the extrusion temperature (die temperature) and the screw speed. The dependent variables used were the overall expansion, bulk density, water soluble index, water absorption index and hardness for each compound individually and in total for all the compounds. Twenty tests were performed: eight tests of factorial points (2^3) (three levels for each factor), six axial points (two for each variable) and six repetitions of the central point (Table 1).

The results from the dependent variables were subjected to multiple regression analysis using design expert software 7.0.0 full version (Stat-Ease, Minneapolis, USA) and coefficients with p values

Table 1
Variables and their levels employed in Central Composite Design.

Experiment	Feed moisture content (X1)		Die temperature (X2)		Screw speed (X3)	
	Coded value	Uncoded value	Coded value	Uncoded value	Coded value	Uncoded value
1	−1	14	−1	140	−1	150
2	1	22	−1	140	−1	150
3	−1	14	1	180	−1	150
4	1	22	1	180	−1	150
5	−1	14	−1	140	1	250
6	1	22	−1	140	1	250
7	−1	14	1	180	1	250
8	1	22	1	180	1	250
9	−1.68	11.27	0	160	0	200
10	1.68	24.73	0	160	0	200
11	0	18	−1.68	126.36	0	200
12	0	18	1.68	193.64	0	200
13	0	18	0	160	−1.68	115.91
14	0	18	0	160	1.68	284.09
15–20	0	18	0	160	0	200