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Physicochemical properties, protein and starch digestibility of lentil based noodle prepared by using extrusion processing

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ABSTRACT

Noodles are popular staple food and its consumption has increased worldwide due to convenience, nutritional quality, sensory attributes, palatability and reasonable price. The present study was aimed to produce nutritional rich extruded noodle with acceptable physical and sensory properties using extrusion processing. Response surface methodology was used to establish the correlation between process variables as moisture content, die temperature and screw speed and physical properties as bulk density, WSI, WAI, cooking time, cooking gain, cooking loss and hardness of noodle. The attempt was also made to study the effect of processing variable on the antinutritional factor and made to assess in vitro protein and starch digestibility. Moisture was in the range of 16–24% and die temperature has been varied from 70 to 120 °C with screw speed of 150–250 rpm at constant feed rate. From result it was observed that, best quality noodle was obtain when 20% moisture, 95 °C die temperature with 150 rpm screw speed. It was also found that the extrusion process for noodle reduces the trypsin inhibitors (97.02%), phytic acid (93.18%) and tannin (92.33%) with improving IVPD (68.24%) and IVSD (75.19%). As starch digestibility increased during extrusion resulted to reduce cooking time upto 4 min 32 s with 4.6% cooking loss.

1. Introduction

Noodles are widely popular staple food in many parts of Asian countries due to the easy cooking methods, safety, desirable sensory attributes, long shelf life and reasonable price and have a history of over 4000 years. Noodle consumption has increased worldwide because of its convenience, nutritional quality, and palatability (Li et al., 2012; Yadav, Yadav, Kumari, & Khatkar, 2014). Noodles are also used as space and emergency food (Gulia, Dhaka, & Khatkar, 2010). Noodles have become globally recognized food and it's consumed in more than 80 countries. Noodle industry supplies 95.4 billion servings per annum to consumers all over the world, and the demands are on the rise. China ranks first in the consumption of noodles followed by Indonesia, Japan, and Vietnam according to the world instant noodle association (WINA, 2011) Although consumption of noodles in India had been low, it has increased appreciably in the past five years, i.e., by more than five times as reported by WINA (2011).

Extrusion of food is promising technology for the food industries to process and produced large number of products of varying shape, size, taste and texture (Kaur, Hundal, & Bakhshi, 2007). Extrusion cooking is used worldwide for the production of noodles, as there is a huge demand of healthy and nutritious instant products from all age groups of consumer. Extrusion conditions such as feed moisture content, extrusion temperature and screw speed were controlled to obtain optimized product quality (Rathod & Annapure, 2015).

Lentil (*Lens culinarisMedikus*) is an important daily food source for humans in number of countries, as they provide both micro and macro nutrients and have a high content of proteins, dietary fibre and carbohydrates (Rathod & Annapure, 2015). Lentils are key source of protein for human body, particularly in parts of the world where meat and milk consumption is constrained by factors such as low availability, ethical reasons or allergenicity. Some researchers suggest that legume based products are essential in our daily diet for leading a healthy life (Boye, Aksay et al., 2010; Tharanathan & Mahadevamma, 2003). Lentils also contain considerable amount of vitamins and other micronutrients (Rathod & Annapure, 2015) and are known to play a key role in preventing metabolic diseases such as growth faltering diabetes mellitus (Boye, Zare, & Pletch, 2010; De Almeida Costa, da Silva Queiroz-Monici, Reis, & de Oliveira, 2006; Simpson et al., 1981) obesity, kidney diseases and coronary heart diseases (Boye, Aksay et al., 2010; Simpson et al.,

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1981). The rice noodle produced from rice flour or mixed with other components, such as starches and hydrocolloids are most popular varieties of Asian noodles, and is extensively consumed all over Southeast Asia (Bhattacharya, Zee, & Corke, 1999; Hormdok & Noomhorm, 2007). But the rice noodles have high content of carbohydrates and low content of dietary fiber (DF) (Puwastien, Raroengwichit, Sungpuag, & Judprasong, 1999), protein and other nutritional value therefore it needs to enhance the protein component of noodle made from it. Now days, consumers are more concerned with health, mostly consumers are discriminating and frequently demands nutritionally rich food in the terms of protein and dietary fiber with fair prices. A considerable or a high number of studies related to noodle qualities have investigated the potential of adding fiber sources to noodles made from wheat. However, much less information is available regarding both protein and fiber rich noodles. A combination of cereals and legumes can produce nutrition rich products (Boye, Zare, & Pletch, 2010). Therefore, the aim of this study was to produce nutritional rich (protein and dietary fiber rich) lentil based extruded noodle with acceptable physical and sensory properties by using extrusion processing. Response surface methodology was used to establish the correlation between process variables such as moisture content, die temperature and screw speed and physical properties such as bulk density, WSI, WAI, cooking time, cooking gain, cooking loss and hardness of noodle. Also attempt were made to study the effect of extrusion process on antinutritional factor for noodle and made to assess in vitro protein and starch digestibility.

2. Materials and methods

2.1. Materials

Commercial lentil (*Lens culinarisMedik*) and rice (*Oryza sativa*) were purchased from agriculture produce market committee (APMC), Vashi, Mumbai, India. The lentil and rice were 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

Moisture content, ash content, protein content, fat content, were carried out by AOAC (1980, 2006) and Carbohydrate was calculated by difference. Starch was determined using the enzymatic method of amylase/amyloglucosidase (AOAC, 1980).

2.2.2. Preparation of sample

Blends were prepared by mixing rice and lentil flour in the ratios of 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80 and 0:100 on a dry weight basis. The blended samples were conditioned to 16–24% (w.b.) moisture by spraying with a calculated amount of water and maintained room temperature and relative humidity constant at 37 ± 2 °C and 70 ± 5%, respectively. The samples were stored in seal pack polyethylene bag at 4 °C overnight and allowed to equilibrate for 24 h before extrusion process. Then optimized blend was used for further extrusion process.

2.2.3. Extrusion process

A co-rotating twin screw extruder (KETSE 20/40 Brabender GmbH and Co. KG, Duisburg, Germany) was used to perform the extrusion process with screw diameter of 2 cm and length of 40 cm with L/D ratio of 20:1. The circular die with 2 mm diameter was used. The material was feed into the extruder using a volumetric feeder. The extruder had four temperature control zones. The temperature during extrusion was adjusted by using electric heaters. Noodle were produced using temperatures in the range of 70–120 °C and screw speeds of 100–200 rpm. The noodle were cooled to room temperature, packed in polyethylene bags and stored in a desiccator till further analysis.

2.2.4. Experimental design

A central composite design (CCD) was used to reveal the effect of process conditions and material characteristics on the final properties of noodles. Feed moisture, extrusion temperature and screw speed was used as independent variables and the dependent variables used were the bulk density, water soluble index (WSI), water absorption index (WAI), cooking time, cooking gain, cooking loss and hardness for each compound individually. Process parameters varied over three levels, as shown in Table 1. Twenty experiments were performed: eight tests of factorial points (23) (three levels for each factor), six axial points (two for each variable) and six repetitions of the central point, as well as a control sample. It is a prerequisite by Response surface methodology (RSM) analysis, using the following equations:

$$X1 = (\text{Moisture content} - 18)/4 \tag{1}$$

$$X2 = (\text{die temperature} - 160)/20 \tag{2}$$

$$X3 = (\text{screw speed} - 200)/50 \tag{3}$$

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	16	−1	70	−1	100
2	1	24	−1	70	−1	100
3	−1	16	1	120	−1	100
4	1	24	1	120	−1	100
5	−1	16	−1	70	1	200
6	1	24	−1	70	1	200
7	−1	16	1	120	1	200
8	1	24	1	120	1	200
9	−1.68	13.27	0	95	0	150
10	1.68	26.73	0	95	0	150
11	0	20	−1.68	52.96	0	150
12	0	20	1.68	137.04	0	150
13	0	20	0	95	−1.68	65.91
14	0	20	0	95	1.68	234.09
15–20	0	20	0	95	0	150