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Effect of feed moisture and extrusion temperature on protein digestibility and extrusion behaviour of lentil and horsegram

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ABSTRACT

Effect of extrusion temperature (ET) and feed moisture (FM) on *in vitro* protein digestibility, protein thermal stability and extrudate characteristics of lentil and horsegram was evaluated. Thermal stability of different polypeptides (PPs) present in both the pulses varied as a function of FM and ET. PPs degradation increased with decrease in FM and increase in ET. Low molecular weight PPs between 13 and 30 kDa of lentils and 37 kDa of horsegram were highly thermo stable and were not affected during extrusion. PPs of 81, 35, 31, 29 and 14 kDa of lentils and PPs of 81 and 78 kDa present in horsegram were thermo labile. Expansion ratio (ER) and lightness (L^*) of extrudates from both the pulses increased with increase in ET and decrease in FM. Lentil extrudates expanded more and were lighter than horsegram extrudates. Oil absorption capacity increased with increase in FM whereas, water absorption capacity decreased with increase in both ET and FM. Foaming capacity of extrudated flours from both the pulses increased whereas viscosity and in vitro protein digestibility decreased with increase in FM and decrease in ET.

1. Introduction

Despite being valuable source of good quality proteins, carbohydrates, dietry fibres, vitamins and minerals, pulses have limited utilization due to the presence of certain antinutritional factors such as phytates, polyphenols, enzyme inhibitors (trypsin, chymotrypsin, and a-amylase) and hemagglutinins (Tiwari & Singh, 2012). Lentil is most widely used and studied legume. On the other hand, horsegram is under-exploited pulse grown extensively in India. A wide range of processing techniques such as autoclaving, radiation, cooking, roasting, dehulling, germination, soaking, cooking, boiling, fermentation, extrusion etc have been employed in an attempt to increase the utilization of pulses (Bishnoi & Khetarpaul, 1994; Frias, Diaz-Pollan, Hedley, & Vidal-Valverde, 1995; Wang, Lewis, Brennan, & Westby, 1997). However, most of these treatments are not readily adaptable because of high operational costs and requirements for large equipment. Thermal processing has previously been suggested to improve the texture, palatability and inactivation of heat labile toxic compounds and enzyme inhibitors in pulses (Sreerama, Sasikala, & Pratape, 2008). Therefore, manipulation of processing conditions in a cost effective manner may be required to remove or reduce unwanted components. Recently, extrusion is becoming popular as a processing technique because of its number of advantages and easily manipulative parameters to improve product quality and acceptability.

Extrusion is a high-temperature-short-time (HTST) physical treatment during which flours or starches are subjected to high temperatures and mechanical shearing at relatively low levels of moisture content (Camire, Camire, & Krumhar, 1990). Protein concentration, moisture content, and the physical and mechanical parameters of the extruder significantly affect the physical and sensory qualities of extrudates (Day & Swanson, 2013) Extrusion promotes cross-linking and polymerization among proteins and starches to form expanded matrices due to shear, heat pressure and oxygen and thus alters protein structure, solubility and digestibility (Li & Lee, 1997). Functional properties like expansion index, water absorption and solubility indices of the product determine texture and sensory properties of products (Oikonomou & Krokida, 2011). These functional properties are effected by extrusion conditions such as FM content, barrel temperature, screw speed, particle size etc. Pre-cooked flour obtained by extrusion cooking has gelatinized starchy component and can be used as baby foods. The particle size of the flour, the moisture content and extrusion conditions are important factors influencing the properties of extruded baby foods

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(Mian, Riaz, Anjum, & Khan, 2007). Studies on effect of extrusion and processing conditions on corn grit have been extensively studied (Shevkani, Kaur, Singh, Singh, & Singh, 2014; Singh, Smith, & Frame, 1998) but studies on lentil and horsegram grit are few. Lentil is popular protein rich pulse whereas horsegram is mainly used as animal feed. Lentil and horsegram flour, protein and starch characteristics differ significantly (Ghumman, Kaur, & Singh, 2016). So the present study was designed to compare the extrusion behaviour, protein digestibility and product characteristics of lentil and horsegram.

2. Material and methods

2.1. Material

Lentil (*Lens culinaris*) and horsegram (*Macrotyloma uniflorum*) were 2013 harvest. Grains were passed through pair of break rollers to obtain grit. The material recovered was passed through 1,180 μm sieve. The fraction that passed through the 1,180 μm sieve was further sieved through 500 μm sieve and was collected and labelled as flour. The material that passed through 1,180 μm sieve but was retained in 500 μm sieve was collected and labelled as grit. The speed of the fast and slower roller was 350 and 232 rpm.

2.2. Proximate composition

Grit and flour were estimated for moisture, ash, protein (N × 6.25) and fat content by AOAC (1990). Carbohydrate content was calculated as difference.

2.3. Pasting properties

Pasting properties of grit were studied by using Anaton Paar Rheo Plus/32 Model MCR-301. Two gram sample in 18 ml distilled water was weighed directly in the aluminium canister. A programmed heating and cooling was used where samples were held at 50 °C for 1 min, heated to 95 °C at 6 °C/min, held at 95 °C for 5 min and cooled to 50 °C at 6 °C/min and again holding at 50 °C for 2 min.

2.4. Extrusion cooking

Grit (2.0 kg) was extruded using Clextral BC21 twin-screw co-rotating extruder (Clextral, Firminy Cedex, France). ET employed was 100 °C, 125 °C and 150 °C and FM was varied for each temperature at 15, 20 and 25 g/100 g. Water was injected downstream from the solid feed ports to the extruder and adjusted to desired FM keeping in mind the original moisture in the raw material. Screw speed (300 rpm) and feed rate (20 kg/h) was kept constant. The die diameter, screw diameter and length/diameter ratio of the extruder was 6, 25 mm and 16 respectively. The extrudates formed were collected, cooled to room temperature and sealed till further analysis.

2.5. Extrudate analysis

The diameter of extrudates was measured as the mean of ten random measurements using a vernier calliper. Hunter Color parameters (L^*, a^* and b^*) of samples were carried out in triplicate, using Ultra Scan VIS Hunter Lab (Hunter Associates Laboratory Inc., Reston, VA, USA). Water solubility index (WSI) and water absorption index (WAI) of extrudates was determined by the method of Anderson, Conway, Pfeifer, and Griffin (1969). Oil absorption capacity (OAC) and water absorption capacity (WAC) of extrudates were determined following the methods described by Ogunwolu, Henshaw, Mock, Santros, and Awonorin (2009). Protein solubility (PS), foaming capacity (FC) and foam stability (FS) of extrudates were determined following method described by Shevkani, Singh, Rana, and Kaur, (2014). Extrudates were also subjected to SDS-PAGE analysis following method of Kaur et al. (2013) using 12 g/100 g resolving gel and 5 g/100 g stacking gel. Blue value of extrudates was determined using method of Takeda, Takeda, and Hizukuri (1983). Particle size distribution of cooked and uncooked 2 g/100 g extrudate flour suspension was measured using Mictrotrac S3500 Particle Size Analyser, (Microtrac Ins. Ltd., USA). The size distribution was expressed in terms of the volumes of equivalent spheres. Pasting properties of extrudates were evaluated as described above in Section 2.3. Average viscosity at 50 °C and 95 °C was calculated.

2.5.1. In vitro protein digestibility (IVPD) of extrudates

In vitro protein digestibility (IVPD) of extrudates was determined using the method of Akeson and Stahmanna (1964). Sample (250 g) in 0.1 mol/L HCl-pepsin solution was incubated at 37 °C for 3 h followed by neutralization and treatment with pancreatin in 0.2 mol/L phosphate buffer (pH 8.0) for 24 h. After incubation, the sample was treated with 10 g/100 g TCA and centrifuged at 10000 × g for 20 min. Protein in the supernatant was estimated using the Kjeldahl method (A.O.A.C.). Protein digestibility (g/100 g) was calculated by the ratio of protein in supernatant to protein in sample as equation:

$$\begin{aligned}\text{Protein digestibility} &= \text{Nitrogen in supernatant}\\ &= \{\text{Nitrogen (in blank)}\\ &\qquad \text{Nitrogen(in sample)}\}*100\end{aligned}$$

2.6. Statistical analysis

The data reported is mean of triplicate observations except expansion ratio which is mean of ten replicates. Two-way Analysis of Variance (ANOVA) was carried out to compare the mean values using Minitab Statistical Software (MINITABv14.12.0, State College, PA).

3. Result and discussion

3.1. Composition and pasting properties of raw material

Ash and protein content of horsegram grit (HG) was 3.35 and 20.29 g/100 g, respectively whereas of lentil grit (LG) was 2.26 and 21.98 g/100 g, respectively (Table 1). Prasad and Singh (2015) reported ash content of 2.9 g/100 g and protein content of 22.5 g/100 g for horsegram. PV, BDV, SBV and FV of LG and HG are shown in Table 1. The pasting curve represents the changes in the behavior of flour paste viscosity with change in temperature and mainly varies with flour composition and characteristics of starch (Shevkani, Singh, Singh, Kaur, & Rana, 2014). LG showed higher PV, SBV and FV and lower BDV and PT as compared to HG. These differences in pasting properties may be attributed to difference in their amylose content and amylose/amylopectin ratio (Doublier & Llamas, 1993). Amylose and lipids assist in maintaining granule integrity; thus stronger disintegration of the swollen starch granules in the presence of low amylose may have resulted in higher BDV and lower SBV for HG (Singh, Nakaura, Inouchi, & Nishinari, 2008).