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Generating functional property variation in lentil (*Lens culinaris*) flour by seed micronization: Effects of seed moisture level and surface temperature

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ABSTRACT

The effects of micronization temperature (115, 130, 150 or 165 °C seed surface) in combination with lentil (green var. Eston) seed moisture level (natural moisture 8% and tempered to 16 or 23% moisture) on the physico-chemical and functional properties of the resulting flour were investigated. An increase in the water holding capacity of the resulting lentil flour was observed at 16 and 23% seed moisture and micronizing temperatures above 130 °C. Higher oil absorption capacity was observed for flours from 16 and 23% seed moisture levels than micronization at 8% moisture. Starch gelatinization was observed only when seeds were micronized at 23% seed moisture level and 18–25% gelatinized starch was found depending on the temperature achieved. Resistant starch percentage and protein dispersibility index of flours decreased with all micronizing temperatures and tempering levels. Endogenous enzyme activities of lentil flour decreased with increasing micronization temperatures as indicated by reduced lipoxygenase and peroxidase activities. The trypsin inhibitory activity was also reduced due to micronization. Differential scanning calorimetry results did not show changes in peak denaturation temperatures for starch and protein except in the flours from micronization treatments above 150 °C. However, decreases in the enthalpy values (8–90%) were observed for both starch and protein peaks. Very low final viscosity values were observed for the flours of lentil seed tempered to 23% moisture and micronized to 150 or 165 °C surface temperatures indicating possible changes in seed protein and starch. Micronization of tempered lentil seed resulted in changes in functional parameters of the resulting flours thereby allowing entry into different applications than the flour of untreated seeds.

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1. Introduction

Lentil (*Lens culinaris*) is a pulse low in fat, rich in carbohydrates, proteins, dietary fibre, vitamins and minerals, and an excellent choice as a component in a healthy diet (Barbana & Boye, 2013). Consumption of pulses has been linked with potential health benefits such as reduced risk of cardiovascular disease, cancer, diabetes, osteoporosis, hypertension, gastrointestinal disorders, adrenal disease, reduction of LDL cholesterol and also obesity (Hu, 2003; Jacobs & Gallaher, 2004; McCrory, Hamaker, Lovejoy, & Eichelsdoerfer, 2010; Philanto & Korhonen, 2003; Tharanathan & Mahadevamma, 2003). Due to these promising nutritional attributes as well as the growing consumer preference for plant-based foods rich in protein, there is a growing interest in value-added processing of pulses, especially to develop new ingredients for food processors. In addition, pulses including lentil provide gluten-free options in product formulations that require textural and water holding functionalities of protein and starch.

Currently, lentil either green or red, is primarily used as whole seed or in split form, and the milled flour is not a standard form used by the food industry. Compared to most other pulses, the bland taste and ease of processing receives highly favourable consumer acceptability ratings for lentil. As it is, the functional and physico-chemical properties of milled lentil vary in a narrow spectrum limiting the range of applications required by the food processing industry. Presence of starch, protein and dietary fibre makes lentil a highly suitable substrate for functionality modifications that could complement the requirements of different product applications. This study was conducted to bring scientific insight into the existing industry process of "micronization" which has the potential to deliver pulse ingredients having broader food processing industry appeal.

Infrared (IR) heat processing has many advantages over conventional heating methods practiced for foods because it is a rapid, clean, safe

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method that directly acts on the food matrix and is free of unwanted by-product generation (Sharma, 2009). The process "micronization" uses IR wavelength (1.8 to 3.4 μm) to achieve temperatures between 750 to 930 °C in a short time with an instrumental setup containing an IR radiator to provide radiant heat (medium wavelength IR) from either specially designed ceramic tiles heated by the energy supply or by the radiating stainless steel filament of the gas burner. The food material to be processed moves on a vibrating conveyor (Fig. 1) and the heating process depends on the distance between the heat source and the product, optical and thermal properties of the product, presence of water vapor in the air and the length of processing time. When IR radiation reaches the food, it can be absorbed, reflected or scattered. The energy absorbed from IR radiation in the range of 2.5 to 1000 μm causes changes in the vibrational state of the constituent molecules of the biological material leading to radiant heating. Water molecules show absorption of incident radiation in a wider range (2 to 11 μm) than the restricted absorption observed for protein (3–4 and 7–9 μm), lipids (3–4, 5.5, 6.5 and 9–10 μm), starch (7–10 μm) and sugars (2.5-4 and 7–10 μm) (Sandhu, 1986). The inter-molecular friction caused due to this vibration results in heat generation and water vapour pressure in the tissues rises. In grain micronization, the increase in internal water vapour pressure causes increase in softness and plasticity of the material resulting in subsequent swelling and rupturing (Fasina et al., 2001; Krishnamurthy, Khurana, Jun, Irudayaraj, & Demirci, 2008). Micronization involves simultaneous heat and mass transfer causing complex chemical and physical changes of the constituents of the material receiving radiation. As a result, micronization considerably reduces the cooking times of legumes such as cowpea, lentil and split peas, thus extending their utilization (Cenkowski & Sosulski, 1997; Mwangwela, Waniska, & Minnaar, 2007). Micronization can be considered as a short time, high temperature heat treatment and employed in the food industry to increase food safety, shelf stability and nutrient availability and also to decrease cooking times of grains and several other products (Cenkowski, Hong, Scanlon, & Arntfield, 2003).

Based on the hypothesis that initial seed moisture level and the surface temperatures achieved in micronization can be the variables to achieve varying degree of changes in the constituent molecules and the interactions between molecules, this study was carried out with the objective of evaluating physico-chemical and functional characteristics of flours obtained from lentil seeds having different moisture levels (original seed moisture 8% and tempered to achieve 16 and 23% moisture) and micronized to reach different surface temperatures (115, 130, 150 and 165 °C).

2. Materials and methods

2.1. Lentil seeds

Small green lentil seeds with the hull on (var. Eston) from the 2009 crop year and grown near Moose Jaw, Saskatchewan, Canada were obtained from InfraReady (1998) Products Limited, Saskatoon, SK. The experimental design consisted of three moisture conditions (8% or original seed moisture, 15 and 25% targeted final moisture) and four micronizing temperatures (115, 130, 150 or 165 °C seed surface temperature). Two replicates of tempering (moisture adjustment) and micronization were done at two different times using the same source of seeds. Each replicate consisted of twelve micronized and one non-micronized (raw) lentil sample. Each seed treatment combination for 3 kg of lentil was replicated two times.

2.2. Seed treatment and flour preparation

2.2.1. Moisture content adjustment or tempering

Seed conditioning to adjust moisture content is referred to as tempering. Deionized water was added to lentil seeds (~3 kg) in polyethylene bags in predetermined amounts according to the AACC (2013) method 26–95.01 (approved Nov. 3, 1999). The following formula was used to calculate the required amount of water.

$$W = [L\,(\text{Moisture}_t - \text{Moisture}_o)] \,/\, (100 - \text{Moisture}_o) \quad (1)$$

Where, W weight of water required (grams), L = weight of lentil seeds (grams),

Moisture_t % moisture content required at tempering, and Moisture_o = % moisture content of seeds before tempering.

The sealed bags were shaken manually for even distribution of water and the moistened seeds were allowed to equilibrate at ambient temperature to achieve the desired moisture content (4–8 h depending on the desired final seed moisture level). Moisture content of lentil seeds before and after this conditioning (tempering) was determined using the AACC (2013) method 44–17.01 (approved Oct. 1, 2003).

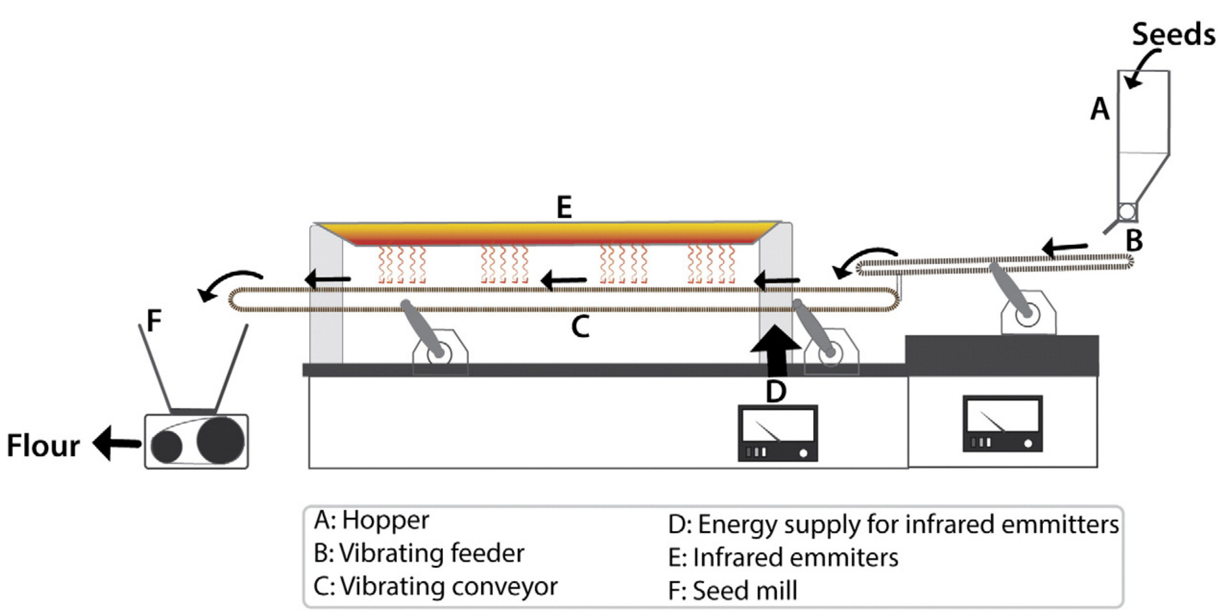

Fig. 1. Schematic diagram of the micronizer used for lentil seed treatment (Adapted from Fasina, Tyler, Pickard, Zheng, & Wang, 2001).

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