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Chemical composition and sensory characteristics of oat flakes: A comparative study of naked oat flakes from China and hulled oat flakes from western countries

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ABSTRACT

Oats are generally considered as a health food and widely accepted by human beings nowadays. Oat flakes are the main commercial oat products around the world. In order to understand the chemical composition and sensory characteristics of the naked oat flakes from China and the hulled oat flakes from western countries, 37 flake samples from China and 44 samples from western countries (8 from the USA, 8 from Canada, 5 from Sweden, 8 from Denmark, 7 from the United Kingdom, and 8 from New Zealand) were investigated in the present study. The results indicated that naked oat flakes showed significantly higher ($P < 0.01$) contents of lipid and Na, a higher level of whiteness ($P < 0.05$) and lower ($P < 0.01$) contents of β-glucan and Fe, compared to hulled oat flakes from western countries. No significant differences of Zn, Ca, and total ash contents were observed between naked oat flakes and hulled oat flakes. In addition, naked oat flakes showed significantly higher water absorption index at room temperature ($P < 0.01$) when compared with hulled oat flakes. Hulled oat flakes showed higher sensory evaluation score than naked oat flakes ($P < 0.01$).

1. Introduction

Oat is considered as a minor grain crop, which contains a high level of nutrients, such as protein, fat, minerals and vitamins. High content of soluble fiber β-glucan in oats has proven effective in preventing heart disease in many researches and the USA Food and Drug Administration (FDA) approved this health claim on January 23, 1997 (Wood, 2011; FDA, 1997). Oats generally can be divided into two categories: hulled oats and naked oats. Due to the beneficial effect of oats and oat products, the hulled oats have been used as breakfast cereals in the form of rolled oats and steel cut groats in western countries for many years (Robert, 1995). In China, oat was used as a traditional Chinese medicine due to its lubricative feature in intestine for hundreds of years (Zhang et al., 2012). It was also used for the elderly, pregnancy women and weak people (Hu et al., 2009). There are about seventy species of oats around the world, while *Avena sativa* L. (hulled oat) and *Avena nuda* L. (naked oat) are the most cultivated oat species (Jing and Hu, 2012).

In China, oats rank around the sixth position in cereal production, after wheat, maize, rice, barley, and sorghum. In 2010, the cultivated area of oats was about 0.7 million hectares, which accounted for 0.57% of total agriculture planting fields and the total yield was 850 thousands tons (Ren and Hu, 2011). In ancient China, oats were mainly planted in the mountain area, dry and semi-dry regions and were mainly consumed as oat flour. Varieties of oat products were emerged into the market recently, such as breakfast cereal, oat flour products, oat rice, oat fermented products, oat milk beverages, and other value added products. Most of the oat products in China, including oat flakes, flour and oat rice are made from naked oats, which have been used to reduce cholesterol level for humans (Wang, 2004; Hu et al., 2009; Ren and Hu, 2011). In China, oat flour accounts for 80% of the total oat products, and only 15% is used for making oat flakes (Ren and Hu, 2011).

According to the processing technology, the oat flakes can be classified into rolled oats (old-fashioned oats), steel-cut oats (Irish oats), quick oats and instant oats (Robert, 1995). In China, the quick oats and instant oats are two dominate products for consumers (Hu et al., 2009). With the booming market demand for oat flakes in China, the characteristics of hulled oat flakes and naked oat flakes are becoming more and more important. However, the previous

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studies mostly focused on the nutritional effects of oats, while the sensory evaluation and the chemical composition differences among oat flakes from different countries were rarely reported (Yan et al., 2013).

The objectives of this study were to investigate the differences between Chinese naked oat flakes and hulled oat flakes from western countries. We prepared 37 naked oat flakes from China and 44 covered oat flake samples from North America (USA and Canada), New Zealand, and European countries (United Kingdom, Sweden, and Denmark). The composition and sensory evaluation of oat flakes were tested.

2. Materials and methods

2.1. Materials

All of the samples were purchased from different supermarkets all over the world and each sample was purchased in 3 specimens. The naked oat flake samples were bought from China in 2011. The hulled oat flakes samples were obtained from Sweden, Denmark, United Kingdom, United States of American, Canada, and New Zealand in early 2012. For each sample, 3 specimens were firstly thoroughly mixed, then half was grinded using a Perten 3303 mill (Perten, Sweden) and stored at − 5 °C for chemical composition testing, while the other half was kept for sensory evaluation tests.

2.2. Methods

2.2.1. Chemical analysis

Moisture content, ash content, β-glucan content (Megazyme Ltd, β-glucan testing kit, Ireland), protein content (N × 6.25, dry basis), and total crude fatty acid content were analyzed according to AACC International Approved Methods 08-16, 32-22, 46-10, 30-10 (AACC, 2000). Energy test was carried out using a GR 3500 energy meter (Changsha High education Instrument Company). Content of calcium, zinc, sodium, iron, and selenium were examined using a Hitachi 280 Atomic Absorption Meter (Hitachi Company, Japan). The whiteness of the flake powder was measured using a Konica-Minolta spectrophotomer CR-310 (Konica Minolta, Tokyo, Japan). Both of the tests were based on the previously described methods by Lu et al. (2009). The CIE L (brightness or lightness), a^* (redness and greenness), and b^* (yellowness and blueness) values were recorded.

2.2.2. Room temperature water absorption index (RTWAI) of oat flakes

The room temperature water absorption index of oat flakes was determined according to previous protocol (2009) and slightly modified. Exactly weighted 20.0 g (W_1) oat flakes in a 250 mL transparent glass beaker, and 150 mL of distilled water were added to the beaker. The beaker was kept in a 25 °C water bath for 20 min. The samples were filtered through filter net for 10 min, and then the samples weighed again, recorded as W_2. Each sample was done twice independently. RTWAI (%) $= (W_2 - W_1)/W_1 \times 100\%$.

2.2.3. High temperature absorption index (HTWAI) of oat flakes

The high temperature absorption index of oat flakes was examined according to previous protocol (2009) with slight modification. 20.0 g (W_1) oat flakes were placed in a 250 mL centrifuge tube, 150 mL of distilled water (room temperature), added and kept in a 80 °C water bath for 10 min. After that, the sample was centrifuged at 3000 × g for 15 min, and the supernatant was collected and its weight recorded as W_2. Each sample was repeated twice independently. HTWAI (%) $= W_2/W_1 \times 100\%$.

2.2.4. Sensory evaluation

The sensory evaluation was examined according to a quantitative sensory profiling method developed specifically for oatmeal samples (Lu et al., 2009) and modified according to Lapveteläinen and Rannikko (2000) for the sensory characteristics of oat flakes (Table 1). Oat flakes were prepared by mixing 20 g of rolled oats (11%, dry basis) with 150 mL boiling water. Samples duplicated 7 times were served on heated (80 °C) plates after 10 min rest until sample assessment. All evaluations were made in individual booths in the sensory laboratory. 9 assessors quantified three physical characteristics (shape and size of flakes, color of flakes before

Table 1
Description language for sensory evaluation of oat flakes.

Term	Definition and score			Evaluation way
Oat flakes before cooked				
Shape and size of flakes (20)	Many broken flakes and with flours, the shape was not uniform, 5-10 score	The flakes were uniform and have bigger flakes, few broken and with few flours, 10–15 score	The flakes size was medium, shape like round or ellipse, and uniform, with fewer flours, 15–20 score	Test the shape and size when the oat flakes were put in the flat plates
Color of flakes (15)	Little dark without brightness, 1–5 score	White or gray with little brightness, 5–10 score	Lightly milk or yellow with brightness, 10–15 score	Test the shape and size when the oat flakes were put in the flat plates
Oat flakes after cooked				
Aroma (10)	Non-fresh smell, or some other flavor without nature roasted oat aroma, 1–4 score	Smell nice and with light roasted oat aroma, 4–7 score	With rich and pure roasted oat aroma, fresh, 7–10 score	Smell the aroma when the oat flakes were warm
Color of flake supernatant (10 score)	Little dark without brightness, 1–4 score	White or gray with little brightness, 4–7 score	Lightly milk or yellow with brightness, 7–10 score	Watch the supernatant without touch the flakes
Mouth feel of supernatant (20 score)	Low viscosity, blank mouth feel, 5–10 score	Medium viscosity, slipperiness mouth feel, 15–20 score	High viscosity, slipperiness and thickness mouth feel, 15–20 score	With the scoop into the mouth, feel the taste and slipperiness of the supernatant
Mouth feel of cooked flakes (15 score)	Adherence to teeth, coarseness, without chewingness, 1–5 score	tender and slipperiness mouth feel, 15–20 score	No adherence to teeth, rich chewingness, tender and slipperiness mouth feel, 10–15 score	With the scoop into the mouth, chewing, feel the texture of flakes
Flavor of cooked flakes (10 score)	Less oat flavor or with non-fresh flavor, 1–4 score	Blank oat flakes, but non other different flavor, 4–7 score	Rich oat flakes smell and endurable, 7–10 score	the supernatant and cooked flakes with the scoop into the mouth, chewing and swallowing, feel the taste