LWT - Food Science and Technology 63 (2015) 1191–1198

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Influence of micronization (infrared treatment) on the protein and functional quality of a ready-to-eat sorghum-cowpea African porridge for young child-feeding

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ARTICLE INFO

Article history:
Received 29 October 2014
Received in revised form
18 March 2015
Accepted 7 April 2015
Available online 15 April 2015

Keywords:
Cowpea
Micronization
Protein quality
Ready-to-eat
Sorghum

ABSTRACT

Indigenous plant foods play a major nutritional and cultural role in the diets of rural people in Africa. However, they can contain high levels of antinutrients, which may exacerbate nutritional and health problems in young children consuming nutrient deficient diets. Also, the rapid increase in urbanization in Africa has led to the need for convenience type meals. This study investigated the potential of micronization (infrared treatment) in combination with extrusion cooking in developing a ready-to-eat sorghum and cowpea based porridge supplemented with cooked cowpea leaves for young child-feeding. Micronization not only inactivated the trypsin inhibitors in cowpea, it also produced an instantized product with excellent hydration properties. When served as a stiff porridge with cooked cowpea leaves in the recommended portion sizes for children aged 2–5 years, one daily serving would meet 40% of the children's protein and lysine requirements. Further, the calculated Protein Digestibility Corrected Amino Acid Score would be comparable to commercial maize-soy instant products. This is notwithstanding that the cowpea leaves had a negative effect on protein digestibility due to their high tannin content. This nutritious ready-to-eat meal from locally available plant foods could contribute substantially to food security in both urban and rural communities in Africa.

1. Introduction

Traditionally, in many resource poor African communities, meals are prepared mainly using indigenous cereals and legumes (Young & Pellett, 1994). The use of legumes and cereals to make composite foods suitable for infant and young child feeding is well founded (Food and Agriculture Organization/World Health Organization, 1994). Sorghum and cowpea are indigenous African pulse-type legume and cereal grains of considerable nutritional and cultural importance in Africa (Anyango, De Kock, & Taylor, 2011). Indigenous green leafy vegetables also make an important contribution to rural African diets, adding high levels of vitamins and minerals (Uusiku, Oelofse, Duodu, Bester, & Faber, 2010). African green leafy vegetables are widely consumed in farming communities in Africa. Traditional dishes made from indigenous African green leafy plants were found to be well-accepted and are consumed by children 7–10 years (Van der Hoeven et al., 2013).

However, these African plant foods have substantial amounts of antinutrients such as enzyme inhibitors, polyphenolic compounds and anti-metals (phytates and oxalates) (Soetan & Oyewole, 2009). Consumption of foods that contain antinutrients by infants and young children can predispose them to malnutrition (Gibson, Ferguson, & Lehrfeld, 1998). This in turn affects the children's immune systems leading to diseases such as pneumonia, diarrhoea, malaria and acute malnutrition (Black et al., 2008).

In addition to these nutritional problems, the rapid increase in urbanization in Africa has led to the need for convenience type meals prepared from easily available foods (De Pee & Bloem, 2009) such as sorghum and cowpea. High Temperature-Short Time

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Abbreviations: CE, catechin equivalent; CP, Cowpeas; CPL, Cowpea leaves; DFS, defatted soy flour; HTST, high temperature-short time; IVPD, *in vitro* protein digestibility; LMW, low molecular weight; MCP 1, Micronized cowpea; MCP 2, Micronized cowpea 2; MRP, Maillard reaction products; PDCAAS, protein digestibility corrected amino acid score; TIA, trypsin inhibitor activity; TIU, trypsin inhibitor units; TPC, total phenolic content; WAI, water absorption index; WSI, water solubility index.

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http://dx.doi.org/10.1016/j.lwt.2015.04.017
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(HTST) extrusion cooking has been used successfully to produce nutritious ready-to-eat meals such as a protein-rich instant porridge (Pelembe, Erasmus, & Taylor, 2002; Singh, Gamlath, & Wakeling, 2007). Another thermal technology, micronization (infrared heating) (Sharma, 2009), has been found to be particularly effective at reducing the cooking time of legumes such as cowpea (Mwangwela, Waniska, & Minnaar, 2006) and eliminating anti-nutrients in cowpea (Khattab & Arntfield, 2009). Micronization has also been found to improve the starch pasting properties of kidney beans, green beans, black beans, lentils and pinto beans (Fasina, Tyler, Pickard, Zheng, & Wang, 2001).

Thus, this study investigated the potential of micronization in combination with extrusion cooking in developing a ready-to-eat sorghum and cowpea based porridge supplemented with cooked cowpea leaves for young child feeding (2–5 years) and the effects of these technologies on the protein quality and functional quality of the meal. The products were compared with a commercial maize-soy composite instant porridge flour.

2. Materials and methods

2.1. Raw materials

Red non-tannin sorghum (cultivar MR Buster) was produced by the Agricultural Research Council, Potchefstroom, North-West Province, South Africa and cowpeas (cultivar Bechuana white) were from Delareyville, North West Province. The grains were cleaned and stored at 4 °C. Young cowpea leaves were handpicked at the Ukulima Research Farm, Limpopo Province. Super (highly refined) white maize meal (Premier, Johannesburg), defatted soy flour (DSF) (Nedan Oil Mills, Potgietersrus) and a commercial instant maize-soy composite porridge flour suitable for children from one year to four years (FUTURELIFE®, Durban) were obtained.

2.2. Sorghum processing

Sorghum grains were decorticated to an extraction rate of 70–80% using an abrasive dehuller (Rural Industries Innovation Center, Kanye, Botswana). The decorticated grains were milled using a hammer mill with a 1.5 mm opening screen size. The milled grains were extruded in a TX 32 twin-screw, co-rotating extruder (CFAM Technologies, Potchefstroom). The feed rate was 30 kg/h and moisture content of the feed was adjusted to 20%. The screw rotation speed was 200 rpm and barrel temperature was maintained between 130 °C and 159 °C with a residence time of 30–90 s. The die diameter was 3 mm and the cutter speed 310 rpm. The extrudate was cooled at ambient temperature for 8 h before being packaged into plastic buckets with tight fitting lids.

2.3. Cowpea processing

Micronized cowpea flour type 1 (pre-conditioned, micronized, cooled, dehulled and then milled).

The cowpeas were pre-conditioned to 41% moisture by steeping in de-ionized water for 6 h and then allowed to equilibrate for 12 h. The grains were micronized using a table top micronizer (Technilamp, Johannesburg). After micronization, the grains were cooled to ambient temperature and then manually dehulled. The dehulled grains were milled using a hammer mill fitted with a 500 μm opening screen and then packed into zip lock-type polyethylene bags and kept at 10 °C.

Micronized cowpea flour type 2 (pre-conditioned, dehulled, micronized, cooled and then milled).

This was prepared by first pre-conditioning as described, after which the grains were manually dehulled. Micronization, milling and packaging of the dehulled grains was as described.

2.4. Processing of cowpea leaves

Cowpea leaves were prepared essentially as described by Faber, Van Jaarsveld, Wenhold, and Van Rensburg (2010) for boiled amaranth. The leaves were washed using running tap water and then cooked in the water remaining trapped between them. The leaves were then frozen at −20 °C. These steps were completed on the day the leaves were picked. They were then freeze dried and stored at 4 °C. Freeze-drying was used simply as a matter of convenience for research purposes as it is the best method of preserving the nutritional quality of fresh produce. In real practice, fresh or air-dried leaves would be used.

2.5. Formulation of meals

Composite flours were prepared from the raw and extruded sorghum flour and the raw and micronized cowpea flours at a 70:30 (w/w) ratio. Composites of sorghum, cowpea flour and freeze dried cooked cowpea leaves were prepared at a 7:3:5 (w/w/w) ratio. Cowpea leaves were included in accordance with recommendations by the Nutrition Information Centre of the University of Stellenbosch (NICUS) (2003) and Vorster, Badham, and Venter (2013) that children's diets should include a high intake of fruit and vegetables in order to provide better micronutrient nutrition.

2.6. Analyses

Protein content (N × 6.25) was determined by Dumas combustion, Method 46-30 (AACC International, 2000).

In vitro pepsin protein digestibility was determined using the procedure of Hamaker, Kirleis, Mertz, and Axtell (1986) as modified by Taylor and Taylor (2002) and using pepsin ≥250 units/mg solid (P7000) (Sigma–Aldrich, St. Louis, MO).

In vitro multi-enzyme protein digestibility was determined according to Hsu, Vavak, Satterlee, and Miller (1977). Samples were digested with trypsin, 13,000–20,000 BAEE units/mg protein (T03030, Sigma–Aldrich), bovine Chymotrypsin type II, 60 units/mg protein (C 4129, Sigma–Aldrich) and Protease XIV, 3.5 units/mg solid (P5747, Sigma–Aldrich).

Lysine was determined by the Pico-Tag method after acid hydrolysis of the protein (Bidlingmeyer, Cohen, & Tarvin, 1984).

Trypsin inhibitor activity was determined according to Method 22-40 (AACC International, 2000).

Total phenolic content (TPC) was determined by a Folin–Ciocalteu method (Waterman & Mole, 1994) with catechin as standard.

Tannin content was determined using the modified Vanillin-HCl method of Price, Van Scoyoc, and Butler (1978) with catechin as standard. Extract blanks were used to correct for highly coloured samples.

Flour water absorption (WAI) and water solubility (WSI) indexes were determined according to Anderson, Conway, Pfeifer, and Griffin (1969).

2.7. Statistical analysis

Data were analysed using one way analysis of variance. Means were compared using Fisher's least significant difference test at a 95% level. All the experiments were conducted three times.