Food Chemistry 200 (2016) 62–68

Contents lists available at ScienceDirect

Food Chemistry

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

Chemical composition and nutritional evaluation of the seeds of *Acacia tortilis* (Forssk.) Hayne ssp. *raddiana*

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ARTICLE INFO

Article history:
Received 9 August 2015
Received in revised form 29 December 2015
Accepted 6 January 2016
Available online 7 January 2016

Keywords:
Acacia tortilis
Seeds
Chemical composition
Antinutritional factors
Functional properties

ABSTRACT

Chemical composition and nutritional evaluation as well as physicochemical and functional properties of seed flour of *Acacia tortilis* (Forssk.) Hayne ssp. *raddiana* were studied. The results indicated that seeds contained 5.30% moisture, 3.99% ash, 9.19% fat, 14.31% fiber, 27.21% protein and 45.30% carbohydrates. Potassium was the predominant element followed by calcium and then phosphorous. Phytic acid, tannins and trypsin inhibitor as antinutrients were detected. The amino acid profile compared well with FAO/WHO recommended pattern except for cystine/methionine, isoleucine, tyrosine/phenylalanine, lysine and threonine. Also, the first limiting amino acid was lysine. Fatty acid composition showed that linoleic acid was the major fatty acid, followed by palmitic, stearic, oleic and arachidic acids. The seed oil showed absorbance in the ultraviolet ranges, thus it can be used as a broad spectrum UV protectant. For physicochemical and functional properties, acacia seeds flour had excellent water holding index, swelling index, foaming capacity and foam stability.

1. Introduction

The growth in food demand and need are the result of the effects of world population growth. In developing countries large groups of the population suffer from protein malnutrition, hunger, famine and their associated disease (Falade, Owoyomi, Harwood, & Adewusi, 2005). To meet these nutritional requirements and continued increases in population, studies are needed to investigate and explore new food sources. In this regard, more attention has been focused on lesser known useful plants as food for human and feed for animals (Ee & Yates, 2013; El-Adawy & Khalil, 1994; Embaby & Mokhtar, 2011).

The genus acacia is a large group of woody species, including shrubs of the family Fabaceae. Also, acacia is one of the plants that have been frequently used as medicine to treat fever, diarrhea, leukorrhoea, haemoptysis and throat infections (Agrawal & Gupta, 2013). The seeds of some acacia species are an important food source for humans and recognized to have economic potential due to the high amount of protein and soluble carbohydrates. For instance, the seeds of both *Acacia nilotica* and *Acacia leucophloea* are known to be eaten by tribal people in India (Siddhwaju, Vijayakumari, & Janardbanan, 1996; Vijayakumari, Siddhuraju, & Janardhanan, 1994).

In Egypt, *Acacia tortilis* (Forssk.) Hayne ssp. *raddiana* is grown in the Sinai area and the common Arabic name is sayyal. The plant tends to grow in areas where temperatures vary from 0 to 50 °C and rainfall is anywhere from about 100–1000 mm (3.9–39.4 in) per year and the seeds are known to be used for animal feed. However, information on the chemical composition, physical properties and nutritive value of *Acacia tortilis* seeds is scanty. Therefore, this study investigated the chemical composition and nutritive value of Egyptian *Acacia tortilis* seeds and evaluated the physicochemical and functional properties of acacia seed flour and oil. This study will provide information on whether or not advisable to incorporate this seed into the human diets.

2. Materials and methods

2.1. Materials

Dry mature seeds of *Acacia tortilis* (Forssk.) Hayne ssp. *raddiana* were collected from three different areas including Ismailia (from the campus of the Suez Canal University), South Sinai and North Sinai, Egypt. Whole seeds from each area were separately ground using an electric mill then used for chemical composition and nutritional evaluation analyses. The coarsely ground seeds were passed through a 0.25 mm sieve to obtain the flour which will be

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http://dx.doi.org/10.1016/j.foodchem.2016.01.019
0308-8146/

used for physicochemical and functional properties determination. At least two determinations were conducted for each sample (from each area) and the range which represents the highest and the lowest value for each component was given. All chemicals and reagents used in this study were of analytical grade and purchased from Sigma–Aldrich Co. (St. Louis, Mo., USA).

2.2. Proximate analysis

Proximate composition of the acacia seeds was determined by using the standard Association of Official Analytical Chemists (AOAC) procedures (2005). Moisture content was evaluated by the loss of weight upon drying in an oven at 100 °C to a constant weight. Ash was assessed by incineration at 550 °C of known weights of the samples in a muffle furnace (Method No. 930.05) (AOAC, 2005). Crude fat was found out by exhaustively extracting a known weight of sample in petroleum ether (boiling point, 60–80 °C) in a Soxhlet extractor (Method No. 930.09) (AOAC, 2005). Protein amount (N × 6.25) was measured by the Kjeldahl method (Method No. 978.04) (AOAC, 2005). Crude fiber quantity was ascertained after digesting a known weight of fat-free sample in refluxing 1.25% sulfuric acid and 1.25% sodium hydroxide (Method No. 930.10) (AOAC, 2005). Carbohydrates were calculated by difference.

2.3. Minerals analysis

Samples were digested with concentrated nitric acid and perchloric acid (4:1, v/v) and heated to 70–90 °C for 10 min and cooled before injection. Minerals including iron (Fe), copper (Cu), manganese (Mn), and zinc (Zn) were estimated in the digested acacia seeds sample, using an Atomic Absorption spectrophotometer (Thermo Electron Corp., S series, AA spectrometer, Type S4 AA system, assembled in China). Potassium (K) and sodium (Na) contents of the digests were determined colorimetrically using Flame photometer model (Jenway Clinical PFP7, Jenway Ltd, Felsted, Dunmow, Essex, UK). Phosphorus (P) content was measured by using the phosphomolybdovanate method (AOAC, 2005). Calcium (Ca) and magnesium (Mg) were assessed by using the titration method with a 0.02 M EDTA solution, according to Chapman and Pratt (1961).

2.4. Antinutritional factor analysis

Phytic acid was determined by the method of Latta and Eskin (1980), as modified by Vaintraub and Lapteva (1988). One gram of the sample was extracted with 50 ml 2.4% HCl for 1 h at ambient temperature and centrifuged at 3000×*g* for 30 min. The clear supernatant was used for the phytate estimation by using the Wade reagent (0.03% solution of $FeCl_3 \cdot 6H_2O$ containing 0.3% sulfosalicylic acid in water) and the absorbance was measured at 500 nm using a spectrophotometer (model 6505 UV/Vis, JENWAY, UK). The concentration of phytate was calculated from the standard curve (using phytic acid), and the results were expressed as gram phytic acid per 100 g (dry matter).

Tannins content was detected using the Folin–Denis reagent according to the method of AOAC (1984). Two hundred milligrams of the sample were extracted with 10 ml of 70% aqueous acetone (v/v) for 24 h. The extracts were centrifuged at 3000×*g* for 20 min and the supernatant was used for the tannins estimation. After adding the saturated Na carbonate solution and the Folin–Denis reagent, the absorbance was measured at 760 nm. Tannic acid was used as a standard compound and the results were expressed as gram per 100 g (dry matter).

Trypsin inhibitor activity (TIA) was evaluated using the procedure of Kakade, Rackis, McGhee, and Puski (1974). One gram of defatted sample was mixed with 100 ml of 0.009 M HCl with shaking at ambient temperature for 2 h. After the centrifugation at 10.000×*g* for 20 min, the clear supernatant was used for inhibitor activity estimation. Trypsin inhibitor activity was determined by using the trypsin solution and the substrate solution (BAPNA), the reaction was stopped by the addition of acetic acid (30%, v/v). The absorbance was measured at 410 nm by using the spectrophotometer and the obtained values from the sample extract were subtracted from the trypsin standard. The trypsin inhibitor content was calculated from the following equation.

$$\text{Ti, mg/g of sample} = \frac{\text{Astd-Asam}}{0.019 \times \text{sample wt., g}} \times \frac{\text{dilution factor}}{1000 \times \text{sample size, ml}}$$

2.5. Amino acid analysis

Amino acid composition was analyzed using High-Performance Amino Acid Analyzer (Biochrom 20, Auto sampler version, Amersham Pharmacia Biotech., Sweden). The sample (100 mg) was hydrolyzed with 5 ml of 6 M HCl in a sealed tube at 110 °C in an oven for 24 h. The hydrolyzed sample was re-dissolved in Na citrate buffer (pH 2.2) and filtered using a 0.2 μm membrane filter then injected into the amino acid analyzer (Baxter, 1996). The contents of the various recovered amino acids were presented as grams per 100 g of protein and were compared with the FAO/WHO (1990) reference pattern.

2.6. Fatty acid analysis

Fatty acid methyl esters (FAME) analyses were prepared according to the method of O'Fallon, Busboom, Nelson, and Gaskins (2007). Fatty acid analysis was performed using a Hewlett Packard Gas Chromatograph (HP 6890 series), equipped with a flame ionization detector and a capillary column, HP5, (30 m; i.d. 0.32 mm; 0.5 μm film thickness). The column temperature was programmed from 150 °C for 1 min then elevated to 235 °C at a rate of 17 °C/min and then raised to 245 °C at a rate of 1 °C/min and hold at 245 °C for 5 min. The injector and detector temperatures were 260 and 275 °C, respectively. Nitrogen was the carrier gas at a flow rate of 1.5 ml/min. Identification of the peaks was achieved by retention times and by comparing them with authenticated standards analyzed under the same conditions.

2.7. Morphological analysis of the defatted acacia seed flour

Scanning electron microscopy (SEM) of *Acacia tortilis* seed flour was carried out using a JSM-5800 LV microscope (JXA-840A ELECTRON PROBE MICROANALIZER, JEOL, TOKYO, JAPAN). Flour samples were sprinkled on adhesive tape, attached to specimen studs and coated with gold (S150A SPUTTER COATER).

2.8. Physicochemical and function properties of acacia seed flour

Bulk density was determined according to the method described by Nwosu (2010). A clean, dry, measuring cylinder was filled with the flour sample and the bottom of the cylinder was tapped on a table until the level could fall no further at the 100 ml mark. The weight of the flour (*W*), which occupied the 100 ml was measured and expressed as a ratio of the volume (*V*). The bulk density was given by:

$$\text{Bulk density} = \frac{W\ (\text{g})}{V\ (\text{ml})}$$