Animal Feed Science and Technology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

Influence of the origin of the beans on the chemical composition and nutritive value of commercial soybean meals

P. García-Rebollar[a], L. Cámara[a], R.P. Lázaro[a], C. Dapoza[b], R. Pérez-Maldonado[c], G.G. Mateos[a,*]

[a] Departamento de Producción Agraria, Universidad Politécnica de Madrid, 28040 Madrid, Spain
[b] Evonik Nutrition and Care, GmbH, 08006 Barcelona, Spain
[c] DSM Nutritional Products Animal, Nutrition and Health, 11740 Singapore, Singapore

ARTICLE INFO

Article history:
Received 1 April 2016
Received in revised form 11 July 2016
Accepted 11 July 2016
Available online xxx

Keywords:
Amino acid profile
Energy content
KOH solubility
Protein quality indicators
Soybean origin
Trypsin inhibitors

ABSTRACT

Commercial samples of soybean meal (SBM) from USA (n = 180), Brazil (BRA; n = 165) and Argentina (ARG; n = 170) were collected from 2007 to 2015 to study the effects of the origin of the beans on chemical composition, crude protein (CP) quality and nutritive value of the meals. Samples were collected at the country of origin or at the arrival of vessels from these countries to Europe. On a dry matter (DM) basis, USA and BRA meals had more CP than ARG meals (532, 532 and 517 g/kg, respectively; $P < 0.001$). On a CP basis, Lys content was higher (6.17, 6.07 and 6.11% CP; $P < 0.001$) in USA than in BRA meals, with ARG meals being intermediate. USA meals had more sucrose (84, 64 and 78 g/kg) and stachyose (64, 53 and 57 g/kg) but less neutral detergent fibre (90, 118 and 102 g/kg) and raffinose (11, 16 and 14 g/kg) than BRA and ARG meals ($P < 0.001$). Ether extract was highest for the BRA meals ($P < 0.05$). Mineral content depended on SBM origin, with BRA meals having more Fe but less Ca, P and K than USA and ARG meals ($P < 0.001$). The AME_n for poultry and net energy for pigs, estimated from published equations, were higher ($P < 0.001$) for the USA meals than for the South American meals. Protein quality indicators varied also with SBM origin. Urease activity was lowest for ARG meals, but the differences were of little practical interest. Protein dispersibility index, KOH protein solubility and trypsin inhibitor activity were higher ($P < 0.001$) for the USA meals than for the BRA and ARG meals. Heat damage indicator, a variable that measures indirectly the incidence of Maillard reactions, was lowest in the USA meals ($P < 0.001$). The correlations among chemical analyses, protein quality indicators and nutritive value traits were numerous and depended on the origin of the beans. The correlation between CP (g/kg DM) and Lys (% CP) contents was negative ($P < 0.001$) for the USA SBM, positive ($P < 0.001$) for the BRA SBM and not significant ($P > 0.10$) for the ARG SBM. In summary, chemical composition, protein quality and nutritive value of the SBM varied widely with the origin of the beans. At equal CP content, USA meals had less fibre,

Abbreviations: AA, amino acid; AID, apparent ileal digestibility; AME_n, apparent metabolisable energy, N corrected; ANF, antinutritional factor; ARG, Argentina; BRA, Brazil; CF, crude fibre; CP, crude protein; CV, coefficient of variation; DE, digestible energy; DM, dry matter; EE, ether extract; HDI, heat damage indicator; KOH, KOH protein solubility; N, nitrogen; NDF, neutral detergent fibre; NE, net energy; NFE, nitrogen-free extract; PDI, protein dispersibility index; SBM, soybean meal; TI, trypsin inhibitor; TIA, trypsin inhibitor activity; TSAA, total sulfur amino acids; UA, urease activity.

* Corresponding author.
E-mail address: gonzalo.gmateos@upm.es (G.G. Mateos).

http://dx.doi.org/10.1016/j.anifeedsci.2016.07.007

more sucrose and Lys and better protein quality than South American meals. Consequently, nutritionists should consider the country of origin of the beans when preparing matrices for evaluating the nutritive value of commercial SBM.

1. Introduction

Soybean meal (SBM) is the main protein source in non-ruminant diets, with USA, Brazil (BRA) and Argentina (ARG) as the major exporter countries. Most nutritionists analyse moisture, crude fibre (CF), crude protein (CP) and urease activity (UA) of the SBM for estimating the nutritive value but usually little attention is paid to the influence of the origin of the beans on the characteristics and nutrient content of the meals. Factors such as bean genotype, planting area, soil type, agricultural practices, and environmental conditions during the growing season and storage, affect the chemical composition of the soybeans (Westgate et al., 2000; Karr-Lilienthal et al., 2004) and consequently the CP, fibre, sugars and mineral content and the nutritive value of the SBM (Grieshop et al., 2003; Ravindran et al., 2014; García-Rebollar et al., 2014). In addition, Frikha et al. (2012) and Ravindran et al. (2014) reported that the amino acid (AA) profile of the SBM varied with the origin of the beans, with USA and ARG meals having more Lys, total sulphur AA (TSAA) and Thr per unit of protein than BRA meals.

Trypsin inhibitors (TI) are the most important antinutritional factors (ANF) present in raw beans. Their inactivation by heat, reduces pancreas weight and increases pancreatic enzyme activity, improving the nutritive value of the meals (Balloun, 1980; Krogdahl and Holm, 1983). However, an excess of heat increases the incidence of Maillard reactions, reducing nutritive value (Fontaine et al., 2007; González-Vega et al., 2011). The determination of TI and Maillard reactions in SBM is tedious, time consuming and expensive. Urease activity, protein dispersibility index (PDI) and protein solubility in KOH (KOH) are the main methods used by the industry for evaluating indirectly the quality of the protein of the SBM. Because of cost and easy implementation, UA is widely used as an indicator of the presence of TI in SBM. Urease, an enzyme present in raw beans, is inactivated by heat at a rate that resembles that of TI (Balloun, 1980; Waldroup et al., 1985) and therefore, high UA is indicative of under-processing of the beans and of an excess of TI remaining in the meal. A low UA, however, indicates either adequate or over-cooking of the meal, because the UA scale does not have negative values. Consequently, when the UA is the only criteria used for determining SBM quality, over-processed meals may pass undetected.

Globulins (glycinin and β-conglycinin) are the predominant storage proteins of soybeans. Globulins are soluble in their native state but their solubility decrease with heat processing. The PDI and KOH measure the solubility of the protein in water and 0.2% KOH solution, respectively. Both methods estimate the extent of denaturation of the protein fraction of the SBM, with high values indicating under-processing and low values indicating over-processing. Araba and Dale (1990) and Parsons et al. (1991) reported that KOH was a good indicator of protein quality. Anderson-Haferman et al. (1992), however, concluded that KOH was not accurate enough to assess under-processed meals. On the other hand, Hsu and Satter (1995), Batal et al. (2000) and Dudley-Cash (2001) suggested that PDI was a more consistent and sensitive indicator of adequate heat processing of SBM than UA or KOH. The heat damage indicator (HDI) quantifies via NIRS technology the effects of heat treatment on the availability of the AA. Most HDI of commercial meals ranges between 0 and 40, with the value of 12 representing the most frequent value in SBM (Evonik, 2010). High HDI values are indicative of damaged protein because of excessive heat treatment.

The aim of the research that is described herein was to study the influence of the origin of the beans (USA, BRA and ARG) on chemical composition, AA profile, protein quality and nutritive value of 515 commercial samples of SBM collected for nine consecutive years.

2. Materials and methods

2.1. Sample procurement

Representative samples (1–3 kg) of SBM were collected from USA (n = 180), BRA (n = 165) and ARG (n = 170) by specialized quality control personnel either at the country of origin (50% of samples) or at the arrival of the vessels to Europe. Only samples processed locally that eventually could reach the European market, were included in the study. Samples were collected for nine consecutive years and the number of samples per country varied with the year of collection (Table 1). The USA SBM were obtained from crushing plants located in the Mississippi river area (n = 96) and the East Coast (n = 36), or at the arrival at the ports of Tarragona and A Coruña (Spain), Hamburg (Germany), Rotterdam (The Netherlands) and Brest (France) of vessels loaded in New Orleans (n = 48). Samples from BRA were collected directly at the country of origin (n = 63), mostly from feed mills in the states of Porto Alegre and Sao Paulo, or in Europe (n = 102) from cargoes loaded at Paranaguá, Santos and Ilheus and unloaded at Brest (France), Hamburg (Germany) and Bilbao and Tarragona (Spain). Samples from ARG were collected from six different local crushing plants (n = 64) or in Europe (n = 106), at the arrivals of cargoes loaded at Rosario and Bahia Blanca to the ports of Marin and Huelva (Spain), Lisbon (Portugal) and Hamburg (Germany). In all cases, samples identity was preserved during the process, with identification of the technician in charge of the sampling, location and date of collection and details on dates and ports of departures and arrivals of the vessels.

Please cite this article in press as: García-Rebollar, P., et al., Influence of the origin of the beans on the chemical composition and nutritive value of commercial soybean meals. Anim. Feed Sci. Tech. (2016), http://dx.doi.org/10.1016/j.anifeedsci.2016.07.007