Available online at www.sciencedirect.com
ScienceDirect
Aquaculture 265 (2007) 218–229
Aquaculture
www.elsevier.com/locate/aqua-online

Evaluation of the influence of drying process on the nutritional value of lupin protein concentrates when fed to rainbow trout (*Oncorhynchus mykiss*)

Brett Glencross [a,d,*], Wayne Hawkins [b,d], David Evans [a,d], Neil Rutherford [a,d], Ken Dods [c,d], Peter McCafferty [c,d], Sofia Sipsas [b,d]

[a] *Department of Fisheries, Research Division, PO Box 20, North Beach, WA 6020, Australia*
[b] *Department of Agriculture, Government of Western Australia, Baron Hay Court, South Perth, WA 6150, Australia*
[c] *Chemistry Centre (WA), 125 Hay St, East Perth, WA 6004, Australia*
[d] *Centre for Legumes in Mediterranean Agriculture (CLIMA), Aquaculture Feed Grains Program, University of Western Australia, Crawley, WA 6909, Australia*

Received 30 November 2006; received in revised form 23 January 2007; accepted 26 January 2007

Abstract

A series of studies were undertaken to examine the effect of drying processes on the composition, digestibility and utilisation efficiencies of different types of lupin (*L. angustifolius* cv. Myallie) protein concentrate when fed to rainbow trout. Three different LPC drying methods (freeze-drying: FD, spray-drying: SD, and heat-drying: HD) were studied. Significant effects of drying process were observed on the composition of the LPC; most notable was the relative increase in the level of crude fibre and decrease in crude protein with the heat-dried product. The digestibilities of each of the LPC were assessed using the diet-substitution method. Each of the digestibility diets were fed to fish of 442±58 g (mean±S.D.), with faecal collection undertaken using stripping techniques. No significant differences in the digestibilities of protein or energy, or total digestible protein and energy concentrations were observed among the LPC. To assess the utilisation of protein and energy, fish were fed diets with a 300 g/kg inclusion level of either the spray-dried or heat-dried LPC. A third fishmeal based reference diet was also used. The diets were formulated to equivalent digestible protein and energy specifications based on predetermined digestibility values for each of the ingredients used. Each of the diets was fed at one of three ration levels and an additional starved treatment was also included. In a 28-day growth study, fish of 96.4±1.7 g (mean±S.D.) kept in freshwater at 13.9±0.2 °C grew in accordance with their ration level, but with some significant differences observed among the diets. The comparison of the three diets in this experiment shows that the dietary inclusion of the heat-dried LPC significantly reduced the efficiency of energy gain. Utilisation of digestible protein at lower digestible protein intake levels did not appear less efficient with the heat-dried LPC, but at higher protein intake levels it was not as efficiently used as spray-dried LPC or fishmeal protein. A greater proportion of the nitrogen excretion from the fish fed the heat-dried LPC diet was observed as urea, supporting that this ingredient was not metabolised as efficiently as the other diets. This study demonstrates that the drying regime used on a processed grain product may not affect the ability of fish to digest the protein and energy from that grain product, but may affect the ability of the fish to utilise the dietary digestible protein and energy of the ingredient.

Keywords: Plant proteins; Fishmeal replacement; Protein concentrate; Protein isolate; Biological value; Protein damage; Malliard products

* Corresponding author. Department of Fisheries, Research Division, PO Box 20, North Beach, WA 6020, Australia.
E-mail address: bglencross@fish.wa.gov.au (B. Glencross).

0044-8486/$ - see front matter.
doi:10.1016/j.aquaculture.2007.01.040

1. Introduction

Lupin (*Lupinus* spp.) meals are one of the ingredients that have been used to reduce reliance on fish meal as the primary protein source in aquaculture diets. Typically it is the kernel meals of lupins that are being used in these diets (Burel et al., 2000; Farhangi and Carter, 2001; Glencross and Hawkins, 2004; Glencross et al., 2004b). However, like many plant protein meals there are limitations to the inclusion level of most varieties of lupins in fish diets, often as a consequence of their inherent protein level not being sufficiently high enough to justify higher inclusion levels. It would be of substantial value if they had slightly enhanced nutritional characteristics, such as higher protein levels and lower non-starch polysaccharide (NSP) levels (Hardy, 1996).

Like many plant protein meals there are also prospective anti-nutritional factors (ANF) in lupin kernel meals (Francis et al., 2001; Glencross et al., 2003; Glencross et al., 2006b). To improve the potential value of lupin meals the development of a series of prototype protein concentrates has progressed and a range of products of varying compositional characteristics have been produced and evaluated (Glencross et al., 2004a, 2005, 2006a). To further develop the commercial potential for these products it was identified that developing cost-effective drying techniques that did not reduce the nutritional value of the product, would be critical to the viability of the product (Dale, 1996; Kingwell, 2003).

A range of drying processes are used, where necessary, to produce both plant and animal protein meals. Among these drying processes, freeze-drying is considered one of the least damaging and is routinely used as a laboratory preparation method for this reason (Petterson et al., 1999). On the other hand, oven drying is well known as being relatively destructive (Van Barneveld et al., 1994a,b; Glencross et al., 2004c). This is particularly so with plant meals, where chemical reactions can significantly reduce the nutritional value of the protein content of the meal through the occurrence of condensation reactions between lysine residues and free-sugars in the meal (Ford and Shorrock, 1971; Erbersdobler, 1977). This reaction is usually referred to as a Maillard reaction (Oste, 1984). Commercial drying processes such as spray-drying and ring-drying are routinely used to dry protein meals such as blood meal, soy isolates and milk proteins (Fellows, 2000). The impact of heat on the nutritional value of a range of raw materials to a range of monogastric species has been reported (Van Barneveld et al., 1994a; Bureau et al., 1999; Medel et al., 2004; Peres et al., 2003; Glencross et al., 2004d). Of these studies, most have reported some changes in digestible nutrient and energy value (Bureau et al., 1999; Peres et al., 2003; Glencross et al., 2004c). Few studies have examined the impact of variations or lack there-of on nutrient and energy availability from heat-treated raw materials. Work with pigs has shown that digestible value and available value are not always directly related (van Barneveld et al., 1994b). This study reports on the nutritional evaluation of several drying processes used to produce protein concentrates from *L. angustifolius*, when fed to rainbow trout, *Oncorhynchus mykiss*.

2. Methods

In the present study two separate experiments were undertaken to evaluate the effects of drying regime on the nutritional value of three lupin protein concentrates. Firstly an ingredient digestibility evaluation was undertaken to measure the digestible protein and digestible energy value of each protein concentrate. Following the digestibility experiment, a second experiment was designed to examine the protein and energy utilisation efficiencies associated with diets where a 300 g/kg amount of each protein concentrate was included. Diets in the utilisation study were formulated to be *iso*-proteic and *iso*-energetic on a digestible basis, based on the outcomes from experiment 1. The objective of experiment 2 being to ascertain whether the protein and/or energy from the protein concentrates was used any less efficiently than that of the fishmeal protein and energy of the reference diet. The specifics of each study and some general methods used are detailed subsequently.

2.1. General methods

2.1.1. Ingredients and ingredient preparation

Composition and source of all of the ingredients used is presented in Table 1. Lupin kernel meal (*Lupinus angustifolius*, cv. Myallie) was obtained from a commercial grain miller and ground to <600 μm particle size. To make the protein concentrates, the kernel meal was solubilised in water and the pH adjusted to 9.0 with NaOH (2.0 M) with vigorous stirring for 60 min. After mixing, the solution was filtered through a 500 μm filter bag to separate the non-solubilised material from the solubilised protein. The protein solution was then brought to a pH of 4.0 with the addition of HCl (2.0 M) to precipitate out the solubilised protein. The protein precipitate was decanted and dried in a freeze