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Effect of dietary canola oil level on the growth performance and fatty acid composition of juvenile red sea bream, *Pagrus major*

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Abstract

This study was undertaken to evaluate the suitability of using refined canola oil as a source of supplemental dietary lipid for juvenile red sea bream (*Pagrus major*). Triplicate groups of 25 red sea bream fingerlings held under identical culture conditions (25 °C, aerated, re-circulated artificial seawater, 30 g/L; 12-h light/12-h dark photoperiod) were fed three times daily to satiation one of four diets with equivalent protein (~46%), energy (~21.9 MJ/kg) and lipid (~15%) content on a dry weight basis for 12 weeks. The diets were identical in composition except refined canola oil (CO) replaced either 0%, 33%, 67%, or 100% of the supplemental dietary lipid content with the remainder originating from pollock liver oil (FO). Thus CO comprised either 0% (diet FO), 25% (CO25), 48% (CO48), or 70% (CO70) of total dietary lipid content. Fish weight gain, specific growth rate, feed intake, feed efficiency, protein and gross energy utilization, and percent survival were not affected by diet treatment. Except for percent moisture which was depressed in CO48 and CO70-fed fish, concentrations of terminal whole body proximate constituents were similarly uninfluenced by diet treatment. Dietary lipid compositions reflected the proportions of CO and FO in supplemental lipid and their respective fatty acid compositions. Whole body fatty acid compositions mirrored those of diet treatments. However, liver polar lipids of the fish suggested, some essential fatty acids such as eicosapentaenoic acid, docosahexaenoic acid and arachidonic acid were preferentially incorporated and regulated, which resulted in a relatively lower degree of difference between diet treatments compared to what was found in whole body lipid. Our findings suggest that refined canola oil is a suitable dietary lipid source for juvenile red sea bream under our test conditions. However, chronic assessments of CO as a supplemental dietary lipid source for red sea bream are warranted to ensure that similar results are obtained without adverse effects on fish health.

Keywords: *Pagrus major*; Canola oil; Lipid; Polar lipid; Fatty acids

1. Introduction

Fish oil (FO) is an invaluable dietary component for fish because it furnishes the essential fatty acids (EFA) such as eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and arachidonic acid (AA) which are needed for optimal growth and development. The constituent fatty acids in FO also influence biological membrane structure and function. Moreover, FO is an important source of lipid soluble vitamins and highly digestible energy (Higgs and Dong, 2000). Indeed, marine fish ingest little carbohydrate as part of their natural diet. Consequently, they are incapable of metabolically

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utilizing high dietary levels of digestible carbohydrate. Thus, lipids are the favoured form of non-protein metabolic energy (Sargent et al., 2002).

Fish species, especially those of marine origin, provide excellent dietary sources of high quality protein, vitamins and minerals. Fish, in particular, contain a relatively high proportion of n-3 highly unsaturated fatty acids (HUFA), which have a wide range of health benefits in humans such as prevention of cardiovascular disease, Alzheimer's disease and abnormal neurological and ocular development (Mozaffarian and Rimm, 2006; Schaefer et al., 2006; Ikonomou et al., 2007). Consequently, global consumer demands for food fish have grown tremendously and aquaculture is playing an increasingly important role to maintain the percent per capita consumption of fish (FAO-FD, 2004; Tacon, 2004). At the same time, global demand for FO for aquafeeds has grown in direct proportion to the increase in aquaculture output. This is particularly true for carnivorous species such as salmon which require high energy (lipid) content diets (lipid $\leq$40% in grower diets) for optimal growth, feed efficiency and minimization of sea water culture time (Steffens, 1993; Hardy et al., 2001). However, the global supply of FO is limited and the prices of FO have been forecasted to rise (Hardy et al., 2001; New and Wijkström, 2002). Plant oil prices today are generally less than those of FO and for reasons related to sustainability, it is not possible to further increase the annual global harvest of pelagic fish stocks and consequently the supply of FO (Barlow, 2000).

Plant oils are rich in C18 fatty acids but unlike FO, the n-3 HUFA (EPA and DHA) are absent. Nevertheless, plant oils are rich in unsaturated fatty acids and therefore are highly digestible (Opsahl-Ferstad et al., 2003). Fish, like other vertebrates, lack the enzymes necessary to synthesize the parent acids of the n-3 and n-6 families of fatty acids namely, linolenic acid (18:3n-3; LNA) and linoleic acid (18:2n-6; LA), respectively (Bell et al., 1986; Tocher et al., 1989; Mourente and Tocher, 1993a, b). These parent acids are abundant in plant oils. However, marine fish species have dietary requirements for both EPA and DHA since they have limited capacity to synthesize these compounds from LNA (Ghioni et al., 1999; Tocher and Ghioni, 1999). Some marine species appear to have a dietary requirement for AA and there may be a need for an optimal balance between EPA, DHA and AA for good growth and normal development (Higgs and Dong, 2000). In Atlantic salmon (*Salmo salar*), alterations between the dietary proportions of saturated fatty acids (SFA), n-3 and n-6 polyunsaturated fatty acids (PUFA) can affect aerobic swimming performance and gill function (McKenzie et al., 1998; Wagner et al., 2004). A study on the European sea bass (*Dicentrarchus labrax*), a marine species, has also shown that dietary inclusion of plant oil (canola oil or palm oil) can positively influence cardio-respiratory and swimming performance (Chatelier et al., 2006).

Recent studies aimed at assessing the merits of using plant oils as partial replacements for FO in diets for marine fish have demonstrated promising results with respect to gilthead sea bream (*Sparus aurata*; Montero et al., 2003; Izquierdo et al., 2003, 2005; Menoyo et al., 2004), European sea bass (Izquierdo et al., 2003; Mourente et al., 2005) and turbot (*Psetta maxima*; Regost et al., 2003). Indeed, short and long-term studies have shown that rapeseed oil can replace up to 60% of the supplemental FO in diets for gilthead sea bream and European sea bass without adverse effects on fish growth, feed efficiency and survival (Izquierdo et al., 2003, 2005; Mourente et al., 2005). More recently, Glencross et al. (2003a) demonstrated that refined canola oil could comprise 40% of the total dietary lipid of juvenile Australian pink snapper (*Pagrus auratus*) without compromising their growth over a 54-day period. Also, in a second study, Glencross et al. (2003b) found that canola oil could comprise up to 68% of the dietary lipid for this species without any adverse effects on fish growth over a 32-day period. Nonetheless, plant oils referred to as canola oil (CO), apart from the aforementioned studies of Glencross et al. (2003a,b) and Chatelier et al. (2006) on European sea bass, have received little attention in marine fish diets.

Canola is the trademark name given to rapeseed cultivars that have been selected genetically to contain low erucic acid content in the oil (<2%) and glucosinolates or antithyroid compounds in the meal (now <30 μmol/g of air dry oil-free meal; Canola Council of Canada, 2004). Like rapeseed oil, CO has an excellent balance between 18:1n-9 (oleic acid), 18:2n-6 and 18:3n-3. Canola is the dominant oilseed crop of Canada, and the oil, along with low erucic acid rapeseed oil, has been shown to be an excellent source of supplemental dietary lipid for finfish, provided that their respective EFA needs have been met (Dosanjh et al., 1984, 1988, 1998; Bell et al., 2001, 2003; Rosenlund et al., 2001; Grant, 2006; Higgs et al., 2006).

The red sea bream (*Pagrus major*), a strictly carnivorous marine fish, is a major finfish species cultured in Japan. In fact, the demand for red sea bream has grown tremendously within the last decade primarily because it is a high-quality *sashimi* grade fish with high market value (Watanabe and Vassallo-Agius, 2003). While extensive research has been done to define the basic nutritional and husbandry requirements for this species, the merits of including alternative protein and lipid