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Determining factors affecting muddy-flavour taint in farmed barramundi, *Lates calcarifer*

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ABSTRACT

A series of studies were designed to examine the possible cause and predisposing factors of "muddy" taint in the flesh of barramundi farmed in cages in a freshwater reservoir in Australia. A preliminary flavour evaluation study confirmed the presence of a muddy-flavour taint issue in the barramundi farmed. This was examined by studying the flavour properties of a series of samples of fish that were freshwater farmed (purged and unpurged), wild (estuarine) and marine-farmed barramundi. No significant differences in flavour attributes and/or acceptability attributes were detected between the wild and farmed barramundi, provided the barramundi was either marine-farmed or purged. However, it was determined that an obvious "muddy" flavour and odour could be detected in the unpurged freshwater origin fish. It was demonstrated that there was a significantly greater muddy-flavour effect in large (~2000 g) compared to small (~400 g) barramundi. It was found that flavour taint was highest in the "belly cut" of the fillet and lower in the "tail-cut" and "shoulder" of the fillet and that there is a strong correlation of flavour taint with fat levels in the various fillet cuts. Assessment of the influence of flavour taint in the presence or absence of the compounds geosmin (GSM) and 2-methyl-isoborneol (MIB) identified that at Lake Argyle, in the Kimberley region of northern Australia that it was likely that MIB was the primary compound causing the problem. Assessment of the sensory thresholds for GSM and MIB was constrained by vagaries in the assessment of GSM and MIB from the test water samples. A test based on the serial dilution of depurated and tainted water was undertaken, with barramundi placed within each treatment and subsequently evaluated for their sensory characteristics. A significant increase in the sensory detection of muddy flavour was observed at a level of 60% taint affected water. This corresponded to a water MIB concentration of between 3.5 and 5.5 ng/L.

1. Introduction

With increasing production of farmed barramundi in freshwater pond systems and cage-systems in tropical freshwater lakes, an incidence of flavour taint has been reported. The taint is reputedly muddy and earthy in flavour, which is characteristic of the presence of the compounds geosmin (GSM) and/or 2-methyl-isoborneol (MIB) (Howgate, 2004). Problems with such flavour taint are well documented in other fish species produced from freshwater systems (Lovell, 1983; Bett, 1997; Zimba and Grimm, 2003; Grimm et al., 2004; Howgate, 2004; Robertson et al., 2005). The GSM and MIB are noted metabolites produced from algae and cyanobacteria found in freshwater systems (Brown et al., 1982; Bett, 1997; Howgate, 2004).

Problems with a similar muddy/earthy taint in freshwater farmed fish have been reported in a range of species, including: largemouth bass (Schrader & Rimando, 2003), white sturgeon (Schrader & Rimando, 2003), Tilapia (Yamprayoon and Noonhorm, 2000), Channel catfish (Lovell, 1983; Zimba and Grimm, 2003; Grimm et al., 2004), shrimp (Lovell and Broce, 1985) and Rainbow trout (Robertson et al., 2005; Robin et al., 2006). Sensory thresholds in water have been reported at 15 and 35 ng/L for GSM and MIB respectively (Howgate, 2004). In fish flesh the threshold appears to vary among fish species with values for GSM ranging from 250 and 10,000 ng/kg and for MIB threshold values ranging from 100 and 700 ng/kg (Yamprayoon and Noonhorm, 2000; Grim et al., 2004; Robertson et al., 2005). The lipid content of the fish is also reported to affect the uptake of GSM and MIB (Howgate, 2004). This feature may be an important aspect of the species variation in GSM and MIB taint, but could also cause variable uptake in the same species, but in fish of different sizes and in also different parts of the fish fillet.

Chemical assessment of GSM and MIB from water is generally considered a routine analysis. However, a reliable method for the assessment of GSM and MIB in fish flesh has been somewhat more difficult. Assessment of other studies from the literature shows that chemical assessment of flesh levels of GSM and MIB is generally unreliable, with recoveries of the order of 30% to 89% being typical among the data reported (Lovell et al., 1986; Yamprayoon and Noonhorm, 2000;

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Robertson et al., 2005). Because of this variability in the assay from fish, and the cost of developing a chemical analysis/test for GSM and MIB, sensory assessment of samples was considered the most reliable means of assessment of fish samples. Where there have been comparisons of sensory and chemical analysis, they have shown sensory evaluation to be a quite robust and reliable method of assessment (Grimm et al., 2004). In some cases, the use of trained animals, also relying on smell, has also been explored for such assessment (Shelby et al., 2004, 2006).

In northern Australia a developing barramundi cage aquaculture industry at Lake Argyle (16°, 07′ 34.68 S, 128°, 44′ 29.09 E) has reported problems with fish possessing a muddy and earthy flavour. Therefore this study was initiated with the intent to confirm the extent of a flavour taint problem in farmed barramundi. This involved the assessment of a range of issues including: a comparison of barramundi from different sources to confirm the existence of a flavour taint problem, the determination of the sensory detection threshold of flavour taint; the characterisation of the variability in flavour taint within the fillet and characterisation of the variability due to fish size.

2. Materials and methods

2.1. Preliminary taint detection trial

Variation of taint among five different fish samples was compared in blind sensory assessment by an untrained sensory panel of 22 people (mixed sex, age range 21 to 60) at the Department of Fisheries Research Laboratories. The fish samples included farmed saltwater barramundi (sourced Catalanos Pty Ltd, Bassendean, WA), wild barramundi (sourced Sealanes Pty Ltd, Fremantle, WA), unpurged farmed freshwater barramundi and farmed freshwater barramundi purged using one of either two treatments. For purging, fish (~2000 g) from cages in the freshwater lake were transferred to the Lake Argyle Industries Pty Ltd (LAI) enclosed hatchery, where they were placed into 2000 L fibreglass tanks, with a white interior. The two purging methods used were using bore water (<1 ng/L in both MIB and GSM) for five days (treatment 1: T1) and a second treatment of fish purged in bore water plus 20 g/L salt for three days followed by 30 g/L salt for two days (treatment: T2).

This assessment was done to confirm the presence of a taint problem. Each sample was compared and rated (0: not present to 5: extreme) against itself and the other four samples by every taster in a pair-wise assessment. This allowed for not only an assessment of each sensory characteristic, but also a degree of direct comparison among each of the samples. All fish samples were provided as fillets and were prior frozen, before being thawed overnight at 4 °C prior to preparation and cooking for sensory assessment. All fish samples, of a similar weight and thickness, were microwaved inside plastic oven bags for the same period of time. Each sample was taken from the dorsal muscle group in each case.

Each sample was provided whilst warm (~75 °C) with a 3-digit blinding code to allow identification of each sample during analysis. Sensory attributes of odour (muddy, weedy, musty), flavour (sweet, sour, bitter, salty), colour (white, brown, yellow, grey), texture (oily, dry, mushy, chewy) and overall acceptance were evaluated. A minimum of five fish from each treatment were used. Each panellist was provided with purified water and plain water crackers to cleanse their palate between samples.

2.2. Trained sensory assessment

For most of the sensory assessment studies, it was decided that using a professional, trained sensory panel would provide the most robust and independent data. Sensory analysis by a trained panel was undertaken, under contract, at the Centre for Food Technology (CFT, Hamilton, QLD). The panel consisted of 10 female judges, aged between 30 and 61, who were experienced with sensory descriptive analysis of foods and beverages.

The panel were trained over four sessions, each of approximately 2 h, to rate a number of defined sensory attributes. A series of 14 aroma, flavour and aftertaste descriptors were chosen. The attributes and sensory analogues that were chosen by the panel to rate the barramundi fillets are given in Table 1. In addition, an 'other' attribute for aroma, flavour and aftertaste was included for the panel to rate if they thought they could detect a property which was not covered by the chosen list of terms.

Frozen samples were thawed overnight at 2 °C prior to preparation for assessment. Slices of barramundi fillet (no skin) were cut from dorsal to ventral direction across the fillet to give a ~20 g portion of fish. Samples were cut starting from the anterior end, such that any unused fillet always remained at the tail end of the fish.

In preparation for sensory assessment fish samples were weighed into foil dishes and covered with aluminium foil sheets (shiny side down) that were pre-numbered with the blinding code. The samples were prepared up to 1 h ahead of time and kept chilled in a refrigerator at 2–4 °C prior to cooking. Samples were cooked no more than 30 min prior to serving. Samples were cooked on an oven tray, in a pre-heated fan-forced oven, at 200 °C for 6 min. After cooking, samples were transferred to a warming oven at ~75 °C until served.

Only three samples were presented to each panellist at any one time so that all the samples would still be hot for sensory assessment. Samples were presented warm (~75 °C) to each panellist in a randomised order. Where there was sufficient flesh from one fish to

Table 1
Sensory attributes and standard descriptors used by Centre for Food Technology in the assessment of aroma, flavour and aftertaste attributes of barramundi

Attribute	Descriptor/analogue
Aroma	
Milky	Similar aroma to a 20 mL solution (33%) of boiled milk served in a small glass vessel
Steamed	Similar aroma to a strip of hot, freshly steamed (with 33% milk solution) chicken breast fillet served in a small glass vessel
Salty sea breeze	Similar aroma to a mixture of sand, shell grit and seaweed served in a small covered plastic cup
Fresh	No standard — defined as smell of recently cooked fresh, white-fleshed fish
Fishy	Similar to aroma of 20 mL of mackerel fillet in brine solution served in a small covered plastic cup
Muddy/earthy	Similar to aroma of 20 g of mud after a shower of rain served in a small covered plastic cup
Other	As defined by individuals as case arises
Flavour	
Sweetness	No standard — defined as sweet flavour experienced when sample in mouth
Milky	No standard — defined as the flavour of warm, diluted milk experienced when sample in mouth
Fresh	No standard — defined as the fresh flavour of recently cooked white-fleshed fish experienced when sample in mouth
Fishy	No standard — defined as the fishy flavour of old white-fleshed fish experienced when sample in mouth
Muddy/earthy	No standard — defined as the flavour of mud/potting mix/earth experienced when sample in mouth
Metallic	No standard — defined as the tingly metallic sensation/flavour that might be caused by a metal spoon experienced when sample in mouth
Other	As defined by individuals as case arises
Aftertaste	
Muddy	No standard — defined as the lingering muddy/potting mix flavour after the sample has left the mouth
Fishy	No standard — defined as the lingering flavour of old white-fleshed fish after the sample has left the mouth
Other	As defined by individuals as case arises