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**Residual levels and risk assessment of eugenol and its isomers in fish from China markets**

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**Abstract:** Levels of eugenol, isoeugenol and methyleugenol were investigated in 216 seawater fish and 321 freshwater fish from wholesale markets. Eugenol was detected in 55 samples with concentrations ranging from 3.11 to 30690 µg/kg. Isoeugenol was detected only in two samples of grouper at concentrations of 1032 µg/kg and 86.2 µg/kg. Methyleugenol was not detected in any samples. The incidence of anesthetic residue in all the samples was 10.6%. The frequencies of species found with anesthetic residue was higher in seawater fish than in freshwater fish, with rates of 19.4% and 4.7%, respectively. The warm seawater fish such as grouper, sea bass, sea bream, pompano, and red drum should be monitored more closely in the future due to the higher detection frequencies and values of these compounds. Although the results indicate that eugenol or isoeugenol have been used as fish anesthetic to assist with fish handling and fish transport in some species, the human health risk is negligible.

**Key words:** fish anesthetic; eugenol; isoeugenol; methyleugenol; survey; health risk

## 1. Introduction

Fish are easily stressed by handling and transport, which can lead to immuno-suppression, physical injury, and even death (Barton, 2002; Conte, 2004; Portz, Woodley, & Cech, 2006). During transport, the survival rate of fish may worsen because of the deterioration of water quality in vessel caused by oxygen consumption and ammonia excretion (Colt, Momoda, Chitwood, Fornshell, & Schreck, 2011; Li et al., 2016; Stejskal, Kouril, Valentova, Hamackova, & Policar, 2009). Fish anesthetics can alleviate the stress of live fish, minimize mobility, prevent injury and reduce metabolism, which greatly improve the survival rate of live fish in handling and transport (Carter, Woodley, & Brown, 2011; Neiffer & Stamper, 2009). Thus, many kinds of fish anesthetics were introduced into aquaculture to assist live fish handling and transport in the last decades, such as tricaine methane sulfonate (MS-222), benzocaine, clove oil, carbon dioxide and so on (Coyle, 2004).

Clove oil, a plant-based natural product, is a widely used fish anesthetic (Cook et al., 2004; Coyle 2004; Li, Adams et al. 2016). Eugenol, isoeugenol, and methyleugenol are the ingredients of clove oil

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