

## Review

# Emerging non-contact imaging, spectroscopic and colorimetric technologies for quality evaluation and control of hams: a review

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The production of hams follows processes in which the characteristics of raw materials and processing conditions influence the quality attributes. The increased use of non-contact evaluation methods leads to a better understanding of the materials and processes involved, resulting in meat products that are safer with improved quality. To satisfy the increased awareness and greater expectation of consumers, it is necessary to improve quality control methodologies. Imaging and spectroscopy are proven technologies that can provide useful information regarding ham quality and the effects of the

processing regime. The aim of this review is to communicate perspectives and aspects, relating to imaging, spectroscopic and colorimetric techniques on the subject of non-contact quality evaluation and control of hams. Moreover, several promising non-invasive techniques and accompanying technological advances are also presented that have the potential to be robust and efficient. Imaging and spectroscopic technologies continue to change at a rapid pace, and the developed techniques can mature into industrial applications with the right integration framework.

## Introduction

Hams are usually cuts of pork that come from the hind leg and may be cooked and served fresh, although most of them are cured in some fashion, i.e., dry-cured and smoked or wet-cured and then cooked or smoked. The *Semimembranosus*, *Biceps femoris*, *Semitendinosus* and *Rectus femoris* are the four most used muscles in pork ham manufacturing. The term ‘ham’ refers to meats originating from the leg, but many ham products are made from other cuts of meat, following a process of injecting, tumbling and heat treatment (Feiner, 2006). Moreover, it should be noted that the same term in some countries refers only to pork; nevertheless it is used worldwide for countless meat products, where brine is added to smaller pieces of meat (Feiner, 2006). Curing is the addition of nitrite and/or nitrate together with salt, in various degrees of comminution and at different processing steps. Curing agents are essential ingredients, because they are responsible for the unique, distinctive properties that characterize cured ham products (Sebranek, 2009). The most basic method of curing is to cover the meat cuts in a mixture of salt and curing agent (dry curing). The salt and curing agents penetrate slowly into the muscular tissue and the process lasts up to several weeks. The procedure can be accelerated by wet curing, in which the meat cuts are either inserted into a brine of salt (immersion curing) or brine is injected into the meat (injection curing) by needles (Honikel, 2007).

There are various production technologies for dry-cured hams, but the basic aim of all is to furnish a product that can be kept at room temperature without jeopardizing health and without risk of deterioration, and to facilitate the development of the desired sensory characteristics (Arboix, 2004). Traditionally, dry-cured hams have been considered as important meat products in the

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