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Assessing quality parameters in dry-cured ham using microwave spectroscopy

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ABSTRACT

Microwave spectroscopy has been applied in numerous non-food industry applications, and recently also in the food industry, for non-destructive measurements. In this study, a dry-cured ham model was designed and chemical analyses were performed for determining water activity, water content and salt content (sodium chloride) for all samples. These chemical parameters were also measured using microwave spectroscopy, with a rectangular microwave cavity resonator. Results indicate that microwave spectroscopy may be a promising technique for determination of water activity, salt content and water content in dry-cured ham using either reflected or transmitted signals.

1. Introduction

Microwave spectroscopy has become a well-known technique in the non-food industry, including applications for determining particulate blend composition on-line, biomedical measurements, and humidity detection (Austin, Gupta, McDonnell, Reklaitis, & Harris, 2014; Bernou, Rebière, & Pistré, 2000; Kim et al., 2012; Mason, Korostynska, Ortoneda-Pedrola, Shaw, & Al-Shamma'a, 2013). Recently, microwave spectroscopy has also been applied in the food industry, and a previous study shows that microwave spectroscopy is a promising technique for determining the water holding capacity (WHC) of raw meat (Abdullah, Cullen, Korostynska, Mason, & Al-Shamma'a, 2014).

Being able to measure different quality parameters during the dry-curing process of ham is also of great interest. Water activity and water content are important parameters for controlling the production and quality of dry-cured meats. The definition of water activity is the current volume and availability of "free" water in a sample, which is given in values ranging between 0 (absolute dryness) and 1 (condensed humidity). Meat products have high moisture content, thus their water activity lies in the upper range of the water activity scale for foods. While fresh meat has water activity above 0.99, the water activity for dried meat products is lower, between 0.92 and 0.80. It is the availability of water for microbial, enzymatic or chemical activity that determines the shelf life of food; with reduced water activity the shelf life and safety of meat products improve (Andrés, Barat, Grau, & Fito, 2008).

Another parameter that is important for controlling the production and quality of dry-cured meat is salt content. While consumers demand lower salt content in dry-cured meat products, the salt content is an important factor for preventing bacterial contamination. The salt content in a dry-cured ham evens out during the process. However, some parts might have higher salt content than other parts in the final product, depending on the thickness of the sample. Being able to control the salt content in different parts of the ham is of great interest for the industry. The methods applied for measuring water activity, water and salt content in dry-cured meat products today are usually destructive, in addition to being time consuming.

Non-destructive and rapid on-line measurements would simplify and improve the production and quality control of dry-cured meat products. The microwave sensor operates in a wide range of microwave frequencies, providing selectivity in real time detection of water activity, salt content and water content. The principle of using microwaves in real-time monitoring is based on the interaction of the matter under test and the electromagnetic (EM) waves. The velocity of the signal is changed by the test object, which attenuates or reflects it. The main advantages of microwave sensors is that it can be implemented cheaply, yet be used for a wide range of applications in a non-destructive and robust manner. Furthermore, microwave sensors are capable of measuring without contact from a short distance, using penetrating waves, without health hazards to personnel.

The aim is to develop an on-line non-destructive instrument for measuring different quality parameters for raw and dry-cured meat, including water activity and salt content. Therefore, the aim of this study was to investigate whether water activity, salt content and water

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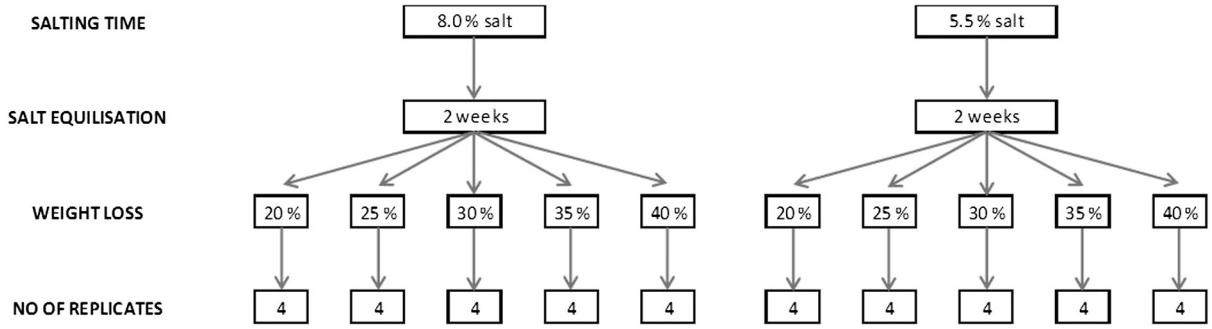

Fig. 1. Design of experiment for the dry-cured ham model analysed in this study.

content can be predicted using microwave spectroscopy. In this purpose, a dry-cured ham model was designed and analysed.

2. Materials and methods

2.1. Sample preparation

Fig. 1 shows the experimental design. Loins from 8 pigs were selected, 4 pigs for the high salt group and 4 pigs for the low salt group. For both high and low salt groups there were five weight loss groups: 20, 25, 30, 35 and 40% loss of initial weight. Generally, dry-cured meat products have 30–35% weight loss in the final product (Fellows, 2000). Each loin was deboned and sliced in a total of 5 meat samples of similar dimensions: approximately 7 cm thick, 5–6 cm high, and 10 cm long. Each loin was therefore represented in all 5 weight loss groups. In order to achieve a final salt concentration of approximately 8.0% in the 30% weight loss group (high salt), all meat samples had 5.5% salt added prior to vacuum packing. For the low salt group all meat samples had 3.85% salt added to achieve a final salt concentration of approximately 5.5% in the 30% weight loss group. All meat samples were stored vacuum packed for two weeks at 4 °C during salting and salt equalization. After salt equalization the meat samples were dried (without vacuum) at 12–14 °C and 72–74% relative humidity (RH) to obtain the desired weight losses. When each meat sample reached the desired weight loss it was vacuum packed and stored at 4 °C until microwave measurements were performed.

2.2. Chemical analysis

Samples for chemical analyses, water activity, sodium chloride content and water content, were taken from each dry-cured meat sample at the same time as samples were analysed using microwave spectroscopy. Water activity was measured by a water activity meter (Aqualab, USA), for all replicates (3) from each of the meat samples. The water and sodium chloride contents were measured by an accredited lab (Eurofins, Norway). The sodium chloride content was calculated using silver nitrate titration of chloride ions (Federation, 1997).

2.3. Microwave spectroscopy

Preparation of samples for microwave analysis was performed as shown in Fig. 2. A slice of approximately 20 mm thickness was taken from the middle of each dry-cured meat sample. From this slice, three replicates were taken with a 25 mm diameter borer (Fig. 3) utilized to cut samples of meat. The meat sample was then placed into polypropylene tubes with a lid prior to measurements. Each of the three replicates was measured 8 times with 1 h interval between measurements. The samples were kept at 4 °C between measurements.

By using a Vector Network Analyzer (VNA) in a two port configuration, it is possible to measure both the power reflected from the sample of matter as well as the power transmitted through the sample. The reflected power is referred to as the S_{11} measurement, and the transmitted power as the S_{21} measurement. Both the power reflected (S_{11}) from and the power transmitted (S_{21}) through the sample were registered at

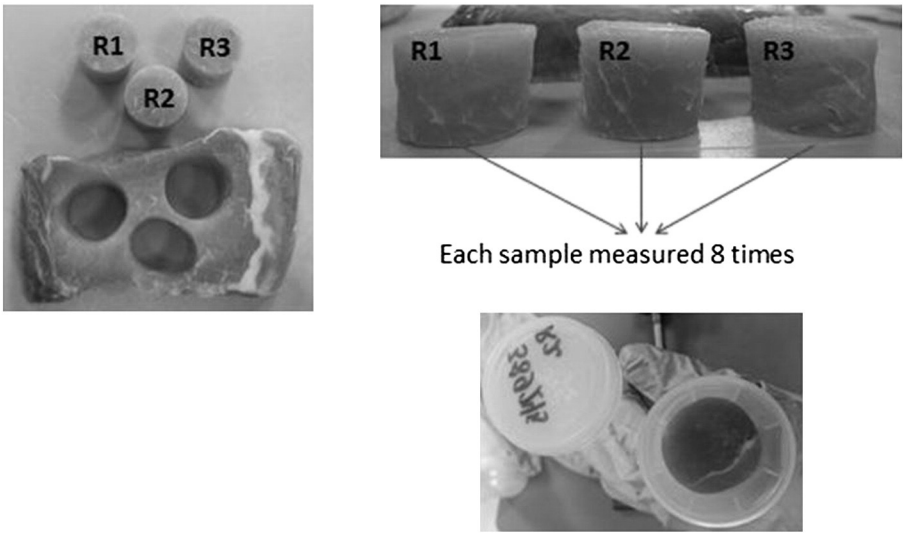

Fig. 2. Preparation of samples for microwave analyses. Three replicates from each dry-cured meat sample were measured eight times with 1 h interval in between.