Meat Science 83 (2009) 278–284

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

A comparison of conventional and radio frequency defrosting of lean beef meats: Effects on water binding characteristics

K.W. Farag, E. Duggan, D.J. Morgan, D.A. Cronin, J.G. Lyng *

UCD School of Agriculture, Food Science and Veterinary Medicine, Agriculture and Food Science Centre, College of Life Sciences, UCD Dublin, Belfield, Dublin 4, Ireland

ARTICLE INFO

Article history:
Received 31 July 2008
Received in revised form 2 March 2009
Accepted 15 May 2009

Keywords:
Radio frequency
Defrosting
Water binding characteristics
NMR
Dielectric spectroscopy

ABSTRACT

The effect of defrosting rate (slow conventional air vs. fast radio frequency (RF) method) on water holding properties of lean beef meat (whole, minced and comminuted) was investigated using a conventional centrifugation method (drip loss), nuclear magnetic resonance relaxometry (NMR) and dielectric spectroscopy. Tempering by radio frequency (RF) or a conventional air method had no subsequent effect ($P \geqslant 0.05$) on drip loss. However, thawing by RF resulted in a significant decrease in drip loss ($P < 0.05$) when compared to air thawing. Micronutrient loss (μg/mL of drip) was also greater in air thawed samples ($P < 0.05$). NMR T_2 distributions did not show any marked difference between thawing methods. The dielectric properties of lean beef, measured from 0.01–20 GHz at 5 °C, were higher following RF thawing. Increased comminution reduced dielectric values, while fine comminution gave an additional fraction in the NMR T_2 distribution. These results provide valuable information on water binding in meat following RF tempering/thawing.

1. Introduction

A number of scientific studies have examined the effect of freezing rate on drip production (Grujic, Petrovic, Pikula, & Amidzic, 1993; Mortensen, Andersen, Engelsen, & Bertram, 2006; Sacks, Casey, Boshof, & Vanzyl, 1993). In contrast the effect of thawing rate on meat drip has received much less attention. Given the economic consequences of high drip loss for processors and its possible quality implications for consumers, this issue needs to be addressed. Radio frequency (RF) technology, which is suitable for rapidly defrosting meat, has received mixed reports in terms of its influence on drip loss. Bengtsson (1963) has claimed thawing lean beef 4 cm thick using a 1 kW RF oven (35 MHz) leading to a reduction in the amount of drip (less than 0.5%) by a modified Grau–Hamm press method. In a separate study, Sanders (1966) also reported thawing 30 kg blocks of meat in 90 min using a 25 kW RF oven which resulted in less than 1% drip loss. While these reports implied reduction in drip using RF, others such as Pizza, Pedrielli, Busetto, Bocchi, and Spinelli (1997) have reported no significant difference in drip loss when thawing boned pork *Longissimus dorsi* muscles using a 4 kW RF oven (27.5 MHz) and a conventional air methods. Jason and Sanders (1962) similarly reported no difference in drip from cod fillet thawed by a 6 kW RF oven (36–40 MHz) or an air method. Freezing and thawing operations can have a major impact on the quality of frozen food particularly in terms of their impact on the cellular structure of food (Ngapo, Babare, Reynolds, & Mawson, 1999). It is suggested that slow thawing causes structural damage through recrystallization and protein denaturation and subsequently reduction in water holding capacity (Ambrosiadis, Theodorakakos, Georgakis, & Lekas, 1994). Recrystallization is a phenomenon that takes place during frozen storage or thawing and refers to any change in size, number, shape and orientation of ice crystals. This phenomenon which has many forms (Fennema, Powrie, & Marth, 1973) is more pronounced during slow thawing when compared to fast thawing (Pérez Chabela & Mateo Oyague, 2004). Slow thawing leads to mechanical damage of the cell membranes and consequently an increase in the drip loss. Alizadeh, Chapleau, De Lamballerie, and Lebail (2007) also reported that when thawing time was reduced the drip loss was reduced which they suggested may have been due to a reduction in recrystallisation rate. Similar results were reported by Chevalier, Le Bail, Chourot, and Chantreau (1999) and Rouille, Le Bail, Ramaswamy, and Leclerc (2002).

Traditionally a range of press, centrifugal and capillary suction techniques has been used to measure the ability of meat to bind water (Trout, 1988). More recently, techniques such as nuclear magnetic resonance (NMR) and dielectric relaxation spectroscopy are being increasingly used in the hydration analysis of food systems (Barringe, Fleischmann, Davis, & Gordon, 1995; Tsoubel, Davis, & Gordon, 1995). Water binding is quantified indirectly using NMR by measuring the relaxation times (τ) of the water molecules in the sample. It was reported that NMR can differentiate between different forms of bound water in meat, the more tightly bound

* Corresponding author. Tel.: +353 1 7167710; fax: +353 1 7161149.
E-mail address: james.lyng@ucd.ie (J.G. Lyng).

0309-1740/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.meatsci.2009.05.010

forms having shorter transverse relaxation times (Lee, Baianu, & Bechtelt, 1992).

Another technique for evaluating water binding is the measurement of dielectric spectra. This method has been successfully used on solid and liquid foods, such as rice, milk, egg white, fish, chicken, agar aqueous gel and gelatin aqueous gel (Miura, Yagihara, & Mashimo, 2003). A broad spectrum pulse of MW radiation (1–20 GHz) is transmitted into the material under test and the reflected energy is analysed. Bodakian and Hart (1994) illustrated how the dielectric spectra could be used to show the difference between raw and cooked beef, the dielectric properties values declining after cooking.

Because of the paucity of information on RF defrosting of meat, the main objective of this study was to compare the effect of defrosting lean beef using RF (rapid) to that of a conventional air method (slow) on drip loss of meat. Another aim of this study was to evaluate water binding measurement techniques such as NMR and dielectric relaxation spectroscopy and to see if they could be related to a traditional centrifugation based measure of water release.

2. Materials and methods

2.1. Raw material and comminution level

Lean beef (95% visual lean) was procured from a local supplier (Kepak, Clonee, Co. Meath, Ireland). It was subsequently exposed to one of three comminution treatments;

(a) non-comminuted: whole meat subjected to tests without any size reduction,

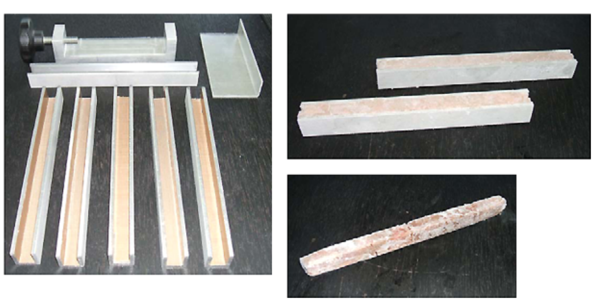

Fig. 1. A specially constructed press for maintaining sample shape during freezing.

(b) moderately comminuted: whole meat ground through a 10 mm diameter plate using a mechanical mincer (Model No. TS8E, Tritacarne, Omas, Italy),

(c) finely comminuted: minced meat as described in (b) was bowl chopped with a Manica bowl chopper (Model No. CM22, Equipaimentos Carnicos, Barcelona, Spain) for 120 s at knife speed one followed by a further 60 s at knife speed two.

2.2. Sample preparation

For drip loss measurement, unfrozen meat from each of the comminution treatments was cut or formed into strips (1.2 × 1.2 × 15 cm) and placed in a specially constructed press (1.2 × 1.2 × 16 cm) (Fig. 1) which was designed to prevent shape distortion during freezing (cold storage room at −18 °C for 48 h). Following freezing the samples were removed from the press and wrapped in cling film. Immediately prior to defrosting the strips were cut into 5 cm length and packed into specially prepared meat blocks in groups of six as described in Fig. 2. The meat blocks (20 × 20 × 10 cm) were cut as shown, the slice removed, and replaced by the packed test strips.

For NMR and dielectric measurements, batches of whole, minced and comminuted beef were packed in 20 × 20 × 10 cm freezer grade cardboard (0.3 cm thick) boxes (Kepak, Clonee Co. Meath, Ireland). Boxes were frozen in a conventional air freezer at −20 °C for 48 h and subsequently maintained at this temperature until required for thawing. Fresh samples of whole, minced and comminuted beef were also prepared for NMR and dielectric measurements to be compared to thawed samples.

2.3. Defrosting method

2.3.1. Radiofrequency (RF) treatment

The RF oven used was a custom built 50 Ω system built by C-Tech Innovation (Chester, UK) using a low power (0.6 kW) RF generator (Model No. RFG 600-27, Coaxial Power System Ltd., Spectrum House, Finmere Road, Eastbourne, East Sussex, UK) and a complementary automatic impedance matching network and controller (Model No. AMN 600-27) at a frequency of 27.12 MHz. The boxed meat was placed at the centre of the bottom electrode and tempered at 500 W for 11 min or thawed at 400 W non-continu-

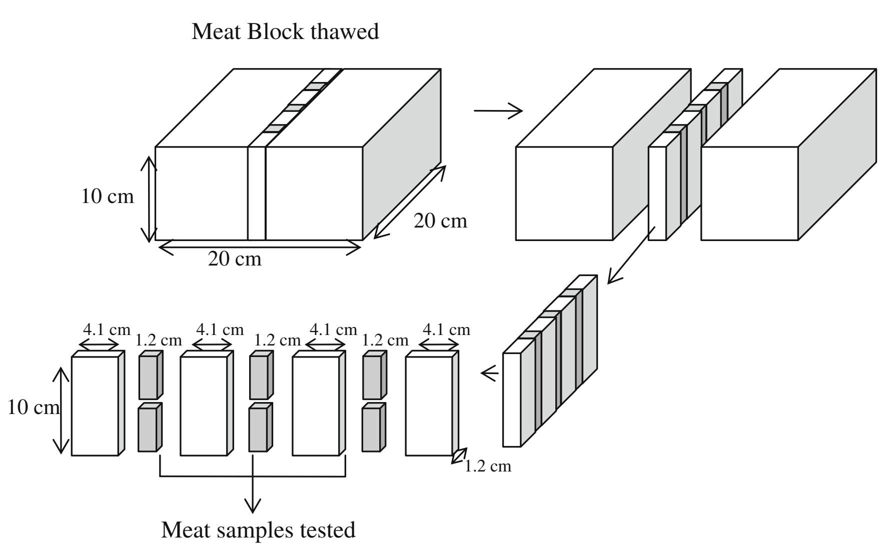

Fig. 2. Illustration of meat samples located in meat block before thawing.