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High pressure effect on the color of minced cured restructured ham at different levels of drying, pH, and NaCl

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ABSTRACT

Color changes of minced cured restructured ham was studied considering the effects of high pressure (HP) treatment (600 MPa, 13 °C, 5 min), raw meat pH_{24} (low, normal, high), salt content (15, 30 g/kg), and drying (20%, 50% weight loss). Raw hams were selected based on pH_{24} in *Semimembranosus*, mixed with additives, frozen, sliced, and dried using the Quick-Dry-Slice® process. Meat color (CIE 1976 $L^*a^*b^*$) and reflectance spectra were measured before and after HP treatment. HP significantly increased L^*, decreased a^*, and decreased b^* for restructured ham dried to 20% weight loss, regardless of salt content and pH_{24}. L^* and a^* were best preserved in high pH/high salt restructured ham. HP had no effect on the color of restructured ham dried to 50% weight loss. HP had no effect on the shape of reflectance curves, indicating that the pigment responsible for minced cured restructured ham color did not change due to HP.

1. Introduction

For meat products, color is one of the most important quality features (Feiner, 2006; Risvik, 1994; Young & West, 2001). During curing of meat, the red pigment nitrosylmyoglobin is formed. Following denaturation, which can take place as a result of heating, fermentation/acidification, or a combination of low water activity (a_w) and high salt content, the stable pink/red pigment nitrosylmyocromogen is formed (Feiner, 2006). Color can further be affected by a number of factors, e.g. meat pH, protein denaturation, and water content (Feiner, 2006).

Sodium chloride (NaCl) is an essential ingredient in processed meat products, affecting factors such as fat-binding, water-holding capacity (WHC), as well as a_w, and thereby shelf-life (Feiner, 2006; Lewicki, 2004). In cured meat products, salt is used in the form of nitrite salt (NaCl with 0.6% $NaNO_2$), which has an antimicrobial effect and is involved in the development of the characteristic color and flavor of cured meat products (Davidson, 2001; Feiner, 2006).

In the traditional production of dry-cured and fermented meat, the drying process is by far the most time-consuming step, ranging from a couple of weeks in small fermented sausages to 1.5–3 years in whole hams, such as the Iberian ham (Arnau, Serra, Comaposada, Gou, & Garriga, 2007). Reducing the time of drying reduces overall processing time, and potentially increases throughput. One way of reducing drying time for sliced, cured or fermented meats is by the Quick-Dry-Slice® (QDS) process. The meat product is frozen when it has reached the desired pH by curing or fermentation. The frozen meat product is then sliced, and dried by QDS (Comaposada et al., 2007). QDS combines convective and vacuum drying in a continuous process, which can reduce drying time for sliced meat products to less than 1 h (Arnau et al., 2007; Comaposada et al., 2007).

In meat science, HP is an emerging processing technique, used mainly for its preservative effects. Pressures in the range of 100 to 800 MPa are applied on meat products (Cheftel & Culioli, 1997), although commercial pressure vessels have a limit at <700 MPa (Torres & Velazquez, 2005). Pressures above 300 MPa help to inactivate microorganisms, making the product microbiologically safer (Davidson, 2001). Meat products are mainly pasteurized, which is generally done in the range 300–600 MPa, inactivating vegetative cells (Aymerich, Picouet, & Monfort, 2008). However, the effect is dependent on temperature. The degree of microbial inactivation is smallest at optimum growth temperatures as opposed to at higher or lower temperatures (Hugas, Garriga, & Monfort, 2002). Furthermore, HP preserves micronutrients better than thermal treatment (Aymerich et al., 2008). However, HP can affect color, texture, and flavor of meat products, which is not always advantageous due to consumer reactions (Cheftel & Culioli, 1997; Fulladosa, Serra, Gou, & Arnau, 2009).

Thus, the objective of this study was to evaluate changes in meat color of minced cured restructured ham considering the effect of HP

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treatment (600 MPa for 5 min) at varying levels of pH_{24}, salt content, and drying level.

2. Materials and methods

2.1. Minced cured restructured ham

The major production steps are depicted in Fig. 1 and more thoroughly described in the text.

Eighteen raw hams were selected from a local slaughterhouse (Esteban Espuña, Olot, Girona, Spain). The raw hams were chosen according to pH_{24h} in *Semimembranosus* muscle, dividing them into three groups (six hams in each group): low ($pH_{24}<5.6$), normal ($5.6<pH_{24}<6.0$), and high ($pH_{24}>6.0$). Each pH group was further divided into two subgroups (meat from three hams in each subgroup). From these six subgroups, 12 batches of 10 kg were prepared according to Table 1. Thus, batches 1 and 3 were prepared from subgroup 1/low pH, and batches 2 and 4 were prepared from subgroup 2/low pH. Batches 5 and 7 were prepared from subgroup 3/normal pH, and batches 6 and 8 were prepared from subgroup 4/normal pH. Batches 9 and 11 were prepared from subgroup 5/high pH, and batches 10 and 12 were prepared from subgroup 6/high pH.

For each batch, the meat was minced with a meat chopper (PM114, Castellvall S.A., Castellar del Vallès, Barcelona, Spain) with a grinding size of 2 mm. Each batch was mixed under vacuum (mixer model AVT50, Castellvall S.A., Castellar del Vallès, Barcelona, Spain) with the following additives (in g/kg meat): 15 g NaCl (low salt) or 30 g NaCl (high salt) (Table 1), 0.15 g sodium nitrite (BASF AG, Ludwigshafen, Germany), 0.15 g sodium nitrate (Laboratori Tècnic Mercader, Torelló, Barcelona, Spain), and 0.5 g sodium ascorbate (Cargill, Rubí, Barcelona, Spain) at 0 °C for 2 min. Next, 10 g transglutaminase/kg meat (Activa EB, Ajinomoto®, Japan) was dissolved in 50 ml water/kg meat and added to the meat mixture to facilitate binding of meat particles during slicing, drying, and packaging (Arnau et al., 2007). Mixing was continued for an additional 2 min.

Table 1
Experimental design: Meat subgroup and sodium chloride (g/kg of meat) used for the 12 different batches of minced cured restructured ham. L = low pH_{24} (<5.6), N = normal pH_{24} (5.6–6.0), and H = high pH_{24} (>6.0) of the raw meat. First digit indicates subgroup, second digit indicates batch number.

pH class	Subgroup	NaCl g/kg		Subgroup	NaCl g/kg	
		15	30		15	30
Low	1	L1.1	L1.3	2	L2.2	L2.4
Normal	3	N3.5	N3.7	4	N4.6	N4.8
High	5	H5.9	H5.11	6	H6.10	H6.12

Immediately after mixing, each of the 12 batches was divided into portions of approx. 2 kg and stuffed into 70 mm artificial collagen casings (Fibran S.A, S. Joan de les Abadesses, Girona, Spain) using a vacuum stuffer (model EC4N, Tecnotrip S.A., Terrassa, Spain). The minced cured restructured hams (from now on simply referred to as restructured ham(s)) were stored for 4 days at 2 ± 1 °C to facilitate the binding process by transglutaminase. Finally, the restructured hams were vacuum packed (model AVT50, Castellvall S.A., Castellar del Vallès, Barcelona, Spain) and kept at −10 °C for at least 1 week.

2.2. Drying by Quick-Dry-Slice®

Each of the 12 batches of frozen restructured ham was sliced into 1.5 mm thick slices (slicer model Scharfen-VA4000AT, Scharfen,

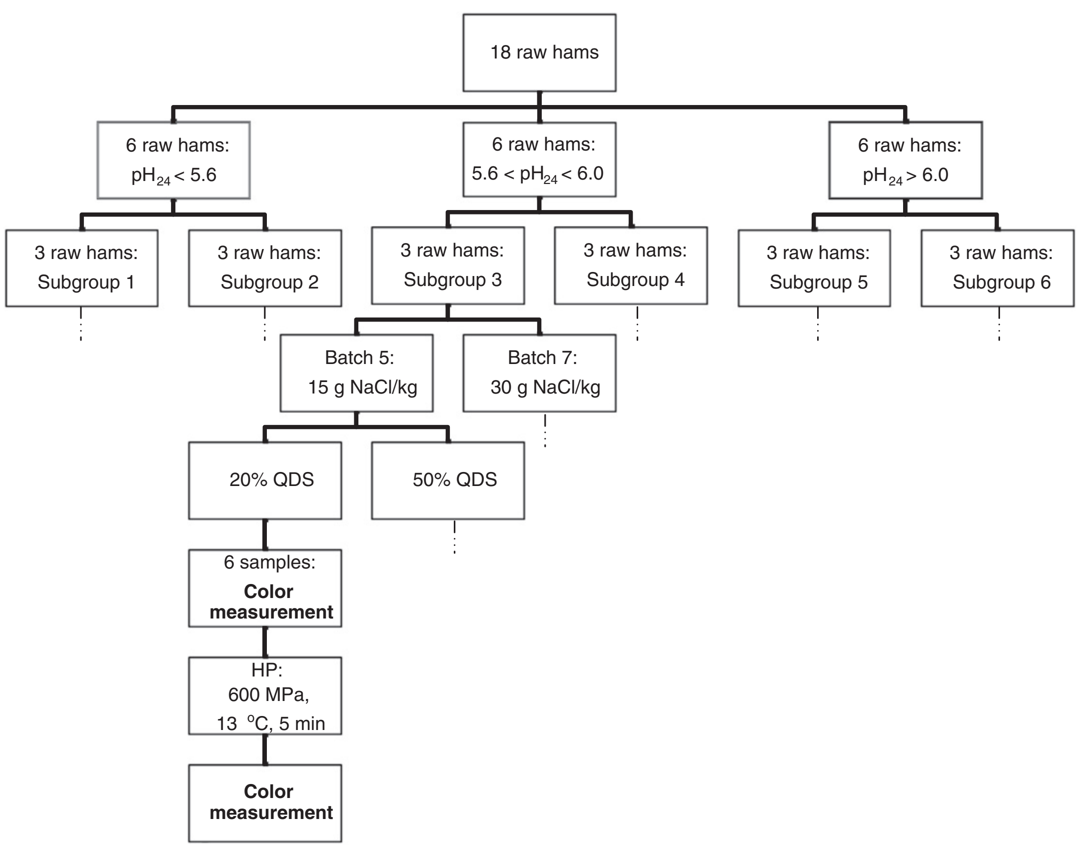

Fig. 1. Flow chart showing the major production steps and points of color measurement for minced cured restructured ham with different levels of pH, NaCl, and drying by QDS. The entire process is only shown for batch 5, one production of normal pH/low salt restructured ham dried to 20% weight loss with QDS, but is similar for all other batches (as indicated by the line and dots).