Effects of the primary process on further processing

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Summary

For several decades there has been an increasing consumer demand for meat products that can be easily and quickly prepared. As a result most poultry meat is sold being cut up, boneless or further processed (i.e. cooked, marinated, formed etc.). A distinction can be made between products that can be recognized as poultry parts, such as fillets, drumsticks and wings, and products that are not directly recognisable as such, for instance formed products. In this latter type of products, poultry is merely used as the raw material source.

The characteristics of the end product depend on the raw material properties interacting with the applied processing conditions. This means that a certain end product requires defined raw material and dedicated processing to achieve optimal results. The raw material properties are influenced by the primary process. However, it is important to realise that in order to achieve the desired end product aspects, such as yields, labour, logistics etc. play a role as well. This paper will discuss some examples of the relationship between primary processing and specified raw material characteristics needed for further processing.

For the marinating and coating of products still covered with skin (wings, drumsticks etc.) skin properties affected by scalding and chilling are important. Scalding temperatures are very critical with respect to the presence of the epidermis, which is essential for optimal further processing.

The moment of de-boning in relation to the amount of energy left in the muscle tissue can be very critical if the meat is to be further processed in line. If there is still some energy left in the muscle, heating will render the meat slightly to unacceptably tough, depending on the amount of energy present. Freezing pre-rigor meat can induce cold shortening. In addition glycolysis will stop. After thawing, glycolysis will start up again, generating energy. Therefore, there is a risk of tough meat if thawed products are heated instantaneously. The boning moment is less critical for the production of fresh meat. The course of the energy depletion varies a lot among birds and flocks, and depends on processing factors such as the way of stunning and the application of electrical stimulation. The large variation in such functional properties among individual bird and flocks make it necessary to

- define the meat source used for further processing studies by examining the course of the processes responsible for these properties
- use sufficient replicates, not just for the experimental units (individual chickens) but also for the tests (flocks).

Introduction

For several decades there has been an increasing consumer demand for meat products that can be easily and quickly prepared. As a result most poultry meat is sold being cut up, boneless or further processed (i.e. cooked, marinated, formed etc.). A distinction can be made between products that can be recognized as poultry parts, such as fillets, drumsticks and wings, and products that are not directly recognisable as such, for instance formed products. In this latter type of products, poultry is merely used as the raw material source.

The characteristics of the end product depend on the raw material properties interacting with the applied processing conditions. This means that a certain end product requires defined raw material and a dedicated processing to achieve optimal results. The raw material properties depend on breed as well as on the primary process (rearing conditions, feed, transport, and slaughter). The desired end-product characteristics can be achieved by selecting suitable raw material or by changing the raw material properties through targeted adjustment of the primary process and/or adapting the further processing. In practical situations, often only weight is used as a criterion for raw material selection. Two examples of how the slaughter process affects raw material characteristics are presented.
Skin properties are important for the marinating and coating of products still covered with skin (wings, drumsticks etc.). Marinade and coating adherence properties depend on the presence or absence of the outer skin layers, i.e. the epidermis, as determined by the scalding and plucking conditions as well as on the level of hydration of the product surface. The texture and tenderness of the meat moment depend on the amount of energy left in the muscle tissue the moment the muscles are de-boned. There can be a risk of exceptionally tough meat, depending on the further processing of the meat. The course of the energy depletion varies a lot among birds and flocks, and depends on processing factors such as the way of stunning, the application of electrical stimulation and the way of chilling.

In this paper some experimental work on both topics is presented.

Experimental work

Light microscopic studies were performed on the structure of chicken skin following scalding and plucking. Products were scalded for 3.5 min either at 50°C (low scald) or 59°C (hard scald). Clear differences in structure were found (Figure 1a,b). Low scald samples have an intact epidermis with multiple keratin layers (cuticle). The surface has a wrinkled appearance. During hard scalding, the entire epidermis is removed and the ‘naked’ dermis is exposed. The dermis has a compact structure with a hyaline (glasslike) appearance, indicating an alteration in surface hydrophobic properties and therefore in marinade and coating adherence properties. For both types of surfaces, dedicated marinade formulations are available.

However, problems with adhesion and coating can occur that are caused by variations in skin surface properties. These variations are due to for instance the level of epidermal damage and mechanically and thermally induced changes in the skin surface. There can be a lot of variation among flocks and products within a flock, as well as within a product, even at fully controlled processing conditions (scalding, plucking and chilling regimen). Factors like genotype, feed, disease (blisters, dermatitis etc.), age, and (local) skin structure, may have an effect on the resistance of the epidermis to thermal treatment.

Shear force analyses were performed to study the effects of in line deboning and further processing (heating and freezing) on the tenderness of breast meat. Tests were performed in a production situation set up for in line aging. Figure 2 shows shear force results of *Pectoralis superficialis* muscles that were deboned at 3 hr post mortem. Carcasses (processed with commercial in line equipment) were either electrically stimulated after plucking (ES) or not stimulated (NES), and left to age for 24 hrs (aged) or immediately heated (direct) after deboning. Stimulated, aged products (ES aged), have low shear values. The non stimulated products (NES aged) have significantly higher shear values. Immediate heating of deboned muscles increases shear force levels considerably. The effect is much more pronounced in the “NES direct” than in the “ES direct” group. In order to give an impression of the variation among flocks and products, the 5, 25, 75, 95% quantiles and the median have been indicated.

Figure 3, shows the variation among 6 flocks (F1 to F6) within the “NES aged” group. The results show significant flock effects as well as a considerable variation in shear force range among the flocks.

Freezing deboned muscle has an effect on shear force as shown in figure 4. Carcasses were either electrically stimulated or not stimulated. They were deboned at 3 hrs post mortem and either left to age for 24 hrs before heating and shear force analyses or immediately frozen at –45°C after deboning (Frozen). The Frozen groups were kept at –20°C for 24 hrs, thawed, and subsequently heated. Muscles left to age on the carcass for 24 hrs before deboning were used as a reference (Control). The results show that freezing muscles deboned at 3 hrs post mortem, will toughen the meat. The effect is most pronounced in muscles that have not been stimulated (NES Frozen). The large range in shear force within this group indicates that there is a lot of variation among flocks and individual birds. Some products are tender, whereas others within the same group are extremely tough. Electrical stimulation diminishes the toughening effect of freezing. Overall, the meat becomes more tender. However, the variation among flocks and products is not reduced.

The results show that in line processing bears the risk of pre-rigor deboning leading to muscle contraction and shortening, and hence, tough meat. Electrical stimulation is known to accelerate glycolysis and energy depletion, i.e. the development of rigor mortis (Kranen et al., 2003). As compared to the “NES aged” group, electrical stimulation has a significant tenderising effect. Apparently, the development of rigor mortis is sufficiently accelerated by the stimulation to avoid muscle contraction and shortening after deboning at 3 hrs post mortem. It also indicates that the moment of deboning in relation to the amount of energy left in the muscle tissue is very critical.
If there is still some energy left in the muscle, heating will render the meat slightly to unacceptably tough. The higher shear force levels of the stimulated group (ES direct), indicate that there is still some energy left in the muscle, allowing heat induced muscle contraction and shortening. In non-stimulated products (NES direct), immediate heating following deboning induces a tremendous contraction, resulting in extremely tough meat.

Freezing pre-rigor muscle inhibits glycolysis and energy depletion (Fisher et al., 1980). During thawing, glycolysis will start up again generating energy. Upon subsequent heating, the muscle will be able to contract and shorten. The result is tough meat. The tenderising effect of electrical stimulation indicates that the amount of residual energy determines the toughness of the meat becomes after freezing, thawing and subsequent heating.

Apparently, there is a lot of variation in energy levels among flocks and products at the moment of deboning, as indicated by the variation in shear force. This variation is likely to be due to the condition of the birds at the moment of slaughter. Although this condition is known to depend on for instance breed, feed withdrawal period, and handling and transport conditions, little is known about causality and interactions. Flock effects may interact with treatment effects in experimental work. Therefore, it is necessary to:

- define the meat source used for further processing studies by examining and describing the course of the processes responsible for these properties
- use sufficient replicates, not just for the experimental units (individual chickens) but also for the tests (flocks).

Research on the correlation and causality between process and product characteristics will form the basis for the development of specific dedicated processes. This will allow the production of distinguished products with a high uniformity in properties and quality. The results of this research can therefore generate possibilities to decrease processing costs and create more added value out of poultry meat.

References


Effects of the primary process on further processing: R.W. Kranen and M.E.T. van Esbroeck

Figure 1a  Chicken skin scalded at 50°C for 3.5 min. White double head arrow: epidermis (E); Black double head arrow: dermis (D); Black arrowhead: cuticle; White arrowhead: germinal layer on basal lamina, boundary layer between epidermis en dermis; F: fibroblasts and connective tissue; A: adipose tissue within the dermis. Bar: 50µm.

Figure 1b  Chicken skin scalded at 59°C for 3.5 min. Bar: 50µm. Black double headed arrow: dermis (D); Black arrowhead: ‘naked’ dermis surface with a compact structure and a hyaline appearance. F: fibroblasts and connective tissue; A: adipose tissue within the dermis. Bar: 50µm. Note the absence of the epidermis.
Figure 2: Shear force measurements of *Pectoralis superficialis* muscles (N=36). Products were either electrically stimulated following plucking (ES) or not stimulated (NES). All muscles were excised at 3 hrs post mortem. They were either left to age for 24 hrs at 4°C (aged) or immediately heated for shear force analysis (direct). Represented are the 5, 25, 75, and 95% quantiles as well as the median. Different letters indicate significant differences (P<0.05).

Figure 3 NES aged group (figure 2): shear force range within flocks (1-6). Individual data are shown. Different letters indicate significant differences between flocks (P<0.05).
Figure 4  Shear force measurements of *Pectoralis superficialis* muscles (N=25). Products were either electrically stimulated following plucking (ES) or not stimulated (NES). All muscles were excised at 3 hrs post mortem. They were left to age for 24 hrs at 4°C or immediately frozen (Frozen). The day after slaughter products were thawed (frozen group) and heated. Represented are the 5, 25, 75, and 95% quantiles as well as the median. Different letters indicate significant differences (P<0.05).