

Effects of stress before slaughter on the quality of poultry meat

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Summary

Stress is a part of life and is probably necessary as an adaptative behaviour susceptible to help living organisms to survive in new environmental conditions. Nevertheless, in many cases, acute stress before slaughter can also have some consequences on edible tissue and then modifies poultry meat quality parameters. In this paper, some of the most known sources of stress susceptible to affect meat quality parameters are reviewed in regard to their consequences on meat quality traits. It seems that, in a common range, acute heat stress, crating and transport or feed withdrawal tend to have limited effects on meat quality parameters while, on the contrary, free struggle associated with shackling affects more deeply meat quality.

Keywords: stress, hormones, feed withdrawal, acute heat stress, transport, struggle

Introduction

According to Moberg (2000) stress can be defined as: "The biological response elicited when an individual perceives a threat to its homeostasis". Many events during rearing as, for example, mixing animals, changing diet, feed withdrawing, new odours, heavy sounds, catching operations, transportation, heat or cold exposures, hanging on the slaughter line, ... can provoke a biological response of the animal suggesting that a new stressful situation has appeared. Most of the time, the animal will find the solution to respond to this stressors but this response can affect its tissues so deeply that consequences can still be visible a long-time after the clinical death. This can be illustrated with stress situations that affect muscle homeostasis in a manner that stress effects will be perceptible through modifications of parameters affecting measurable qualities of meat.

The main purpose of this short review is to try to make a state of the art on the origins of acute stress in poultry, their potential consequences in live animal, and their final impacts on meat quality parameters.

Biological responses to stressors

The stress response is generally divided into three stages which are the detection (with sensorial organs) of the stressor, the organisation of the response developed to maintain the homeostasis and the response itself. The first step implies that the stressor must be perceived by the animal. This signifies that a given stressor can, or cannot, affect different animals only because they are, or not, able to detect such level of stress. In consequence, stressors are not universal and their influence could vary from one individual to another. In the second step, the organisation of the response to stressors can follow three different ways: i) the first one involving the behaviour which will make the animal trying to avoid the stressor. ii) the second one requires the autonomic nervous system and has for consequence increased heart rate, blood pressure, mobilisation of energy sources (glycogen)... iii) the third one implies hypothalamus and is mediated by hormones. It can be divided in two waves of responses: i) alarm reaction = Immediate responses (msec to sec) and is relayed by epinephrine and nor-epinephrine. ii) adaptative reaction = delayed response (min to h) and is relayed by glucocorticoids such as corticosterone or cortisol.

If all those responses turn the homeostasis back to a normal level, we will speak about an adaptative response while if not, we will speak about distress which is a threatening stress. If the distress lasts, it can be considered as a pathological state and therefore lead to worst consequences as decreasing growth performances or reproductive success, leanness and finally death.

Stress before slaughter and meat quality

Stress before slaughter refers to events, susceptible to modify homeostasis possibly to an allostasis state, occurring within the hours prior to slaughter (here approximately limited to 24 hours before slaughter). Nevertheless, we must not also underestimate delayed effects of chronic stress which exist during the rearing period, such as heat or cold exposure, poor feeding, high density rearing, suffering from lighting programs or thirst, etc..., and the possible interactions between that chronic stress and an acute one added just before slaughter.

Since the pioneer works on stress, by Selye (1950), showing that stress is mediated via increased secretion of hormones, many works have been conducted to elucidate the mechanisms of action of those stress mediators.

Hormones

Few recent studies have been conducted specifically on the injection of epinephrine in poultry to mimic its increase during stress. Wood and Richards (1975) demonstrated that epinephrine injection depleted muscle glycogen while ATP remained high, permitting considerable muscle tension development (i.e. toughening) during post-mortem time. In 1997 and 1998, Kannan et al. investigated the effects of corticosterone added in the feed (15 ppm) 48h prior to slaughter to appreciate the effect of a rise in plasmatic corticosterone (+60%) prior to slaughter. This rise is approximately the same as the one observed after 3 h of transport. Few consequences on the quality of pectoralis major (PM) meat were observed (no effects on pH values, cooling loss or texture) except for L* (increased) and a* (decreased) values leading to a paler breast meat positively correlated with the circulating level of corticosterone. More recently, Gao et al. (2008) and Lin et al. (2007) administrated corticosterone (subcutaneous injection, 4 mg/kg of body weight) 3 h prior to slaughter. Here again, despite the well known effect of glucocorticoids in stimulating the release of energy store, no significant effects of corticosterone on muscle pH values were recorded. This indicates that

prior to slaughter, muscle homeostasis regulation is well controlled and that birds have sufficient glycogen store to ensure a good pH drop. On the contrary, protein metabolism seems to be largely modified by an acute stress prior to slaughter leading to modifications of the buffering capacity of the muscle as well as modifications of drip loss. For the moment, very few is known on muscular protein metabolism in response to acute stress before slaughter but much more attention should be given to that important point concerning proteolysis, particularly with regard to further processing products. One other spectacular effect of the increase of corticosterone prior to slaughter is the increased body weight loss observed.

Acute heat stress (AHS)

Chronic heat stress is one of the major environmental factors influencing poultry production. Nevertheless, broilers can also suffer from short heat exposure as demonstrated by Mitchell et al. (1995) who exposed birds to an ambient temperature of 32.6°C for 90 min and reported significant increase in plasma creatine kinase activity which signs a specific tissue dysfunction and damage. Nevertheless, for Petracci et al. (2001), who submitted broilers to AHS (34°C for 12h) prior to slaughter, no dramatic effects on breast meat quality (pH values, meat colour, texture, cooking yield, R-value) were recorded while it causes high effects on live bird shrink and carcass yields. Sandercook et al. (2001) gave the same conclusions for breast meat sensory properties as well as pH or drip loss values.

Crating and transport

Crating includes necessarily a step of catching of the animals which is often a source of physical injuries which downgrades the quality of the carcass (Fletcher, 2002). Because crating, or animals manipulations, causes an increase in plasma corticosterone levels in broilers (Kannan and Mench, 1996), it can be hypothesised that it will modify the quality of poultry meat. However, in broilers, Kannan et al. (1997) reported that crating duration did not affect plasma corticosterone level, cooking losses and shear values of breast or thigh muscle, while it increases the Hue value of thigh meat but had no effects on breast meat. For transportation, Mitchell et al. (1992) reported an increase in plasma CK level in transported birds but failed to demonstrate its significance. More recently, Delezie et al. (2007) also reported that stress before slaughter such as feed withdrawal, crating density and transport had no effects on meat quality parameters while some plasmatic indicators of stress were modified. For those authors, crating density is a very important parameter which can overrule the feed withdrawal and transport effects. This low influence of

transport *per se* on meat quality parameters is also reported by Debut et al. (2003) in broilers, or Owens and Sams (2000) in turkeys, because they did not notice a lot of modifications of meat quality parameters despite some small alterations in initial or ultimate pH values. Nevertheless, most of the authors reported a muscle effect indicating that red (thigh) muscles tend to be more sensible than white (breast) ones.

Feed withdrawal

To reduce carcass contamination, the gastrointestinal tract needs to be emptied (Baracho et al., 2006). In birds, the total feed withdrawal (FW) might be around 8 to 10 h prior to slaughter but in practice longer periods often occur (Shawkat et al., 2008). Edwards et al. (1999) demonstrated that after 24h of FW, liver glycogen markedly decrease whereas muscle glycogen decreased only slightly and transiently. This means that regulation of avian muscle glycogen stores are only slightly affected by FW and we can wonder if it really impacts meat quality. For Van der Wal et al. (1999) moderate FW (8 h) will decrease live body weight but not slaughter, evisceration and oven-ready yields. Meat quality parameters also seemed to be not affected by short FW times as reported by Savenije et al. (2002), Delezie et al. (2007) or Sams and Mills (1993) for breast muscle pH, R-value, shear force, water holding capacity or colour values. On the contrary, Kotula and Wang (1994) indicated that feed withdrawal in excess of 6 hr resulted in a significant and important decrease in the tenderness of breast meat. In consequences, we can conclude that for reasonable duration of FW (not more than 10 to 12 hr), stress effects are very limited at muscle level and do not affect meat quality.

Shackling and struggle

In most of the European slaughter houses, birds are stunned by electronarcosis in a water bath after being hanged in an inverted position which may result in violent wing flapping in some birds and would probably also increase the plasma corticosterone response (Kannan et al., 1997). In 1978, Froning et al. already reported that free struggle turkeys were noted to have a lower muscle pH associated with higher shear values and lower L* and higher a* values were recorded in uncooked white and dark meats. More recently, Berri et al. (2005) reported that wing flapping duration between hangings and stunning was strongly negatively related to early *pectoralis major* muscle pH measurements. For meat quality parameters, reported results indicates that alterations are strongly dependent from the genetic origin of the birds, and that slow growing birds (SGB) are more affected by struggling than fast growing ones. Then, struggling tended to decrease L* and b* values and increases a* and drip loss values in SGB. There is an influence of the genetic origin of the birds on the stress responses of the muscle susceptible to affect meat quality.

This is probably mediated via behavioural response because when hanged in an inverted position, only some birds produce violent wings flapping which is considered as an escape behaviour related to fear levels in individual birds (Kannan et al., 1997a).

Conclusion

As reported here, acute stress before slaughter can more or less affect meat quality traits in poultry. However, stress is necessary for life and it could be desirable to reduce it but not absolutely necessary to suppress it. This can be done with regard to humane considerations for limiting animal pains but also for increasing productivity by limiting global metabolism perturbations (affecting growth, health, success of reproduction, etc) or alterations of poultry product properties. Until now, several papers have described many ways to reduce stress before slaughter (reducing FW length, limited transportation, reduced crating density, avoiding acute heat stress, reducing shackling and/or struggle duration, etc....) but they are not all compatible with commercial requirements. In consequence, we must still work on stress (chronic or acute) physiology at the muscle level to propose new and original (Genetics? Feed supplementation? Behaviour?) methods of rearing that could reduce the reactivity of animals to stress situations and thus the impacts of pre-slaughter handling on meat and carcass quality.

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