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Parameters of Physiological Responses and Meat Quality in Poultry Subjected to Transport Stress

Jing Qi[1*], Yaru Zhang[2], Zixiong Zhou[1] and Umma Habiba[1]

[1]*College of Veterinary Medicine, Chonbuk National University, Iksan, Republic of Korea*

[2]*College of Veterinary Medicine, China Agricultural University, Beijing, China*

[*]**Corresponding author:** Jing Qi, 1College of Veterinary Medicine, Chonbuk National University, Iksan, Republic of Korea, Tel: 01048891681; E-mail: qijingvet@163.com

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Abstract

Transport is unavoidable before slaughter in the poultry industry. The birds may be exposed to various stressors during transport, including birds health condition, fasting, handling, (un)loading, crating density, transport time, vehicle design, trailer microclimate and lairage time. To cope with transport stress, poultry develops physiological responses, which may subsequently affect meat quality and mortality. The paper aims to investigate the effects of transport duration, trailer microclimate and loading density on physiological responses and meat quality of birds. Transport is likely to cause high stress level and energy consumption in poultry according to physiological parameters. The impacts of transport stressors on meat quality are inconsistent or even contradictory. To get consistent results of meat quality following transport, unified measurement methods and the transport conditions are demanded. Furthermore, future research needs to pay more attention to the effects of transport under cold temperature and loading density on poultry to improve their welfare and reduce economic loss.

Keywords: Transport stress; Poultry; Parameters; Physiological responses; Meat quality

Introduction

The increased rearing number of poultry and the demand for poultry to be centered and slaughtered in processing plants make transport a critical constituent in poultry industry all over the world. Recently there are various concerns about poultry transport due to these three major facts [1,2]. Firstly, mortality may be raised by different transport. Secondly, stressful transport reduces poultry welfare. Thirdly, transport decreases meat quality.

However, transport stressors include feed and water withdrawal, handling, (un)loading, crating density, transport time, ambient temperature, vehicle design, trailer microclimate and lairage time. Among them, transport duration, trailer microclimate and loading density are the three main causes of mortality of birds [3-5].

Stress is regarded to be adaptive or protective responses in body, which protects animals from adverse effects of the stressors. Stress responses, including transport stress responses, are mediated by the two major physiological systems, the Sympatho Adrenal Medullary System (SAMS) and the Hypothalamic–Pituitary–Adrenal Axis (HPA). This can alter the physiological states of animals and subsequently affect meat quality. Transport stress impacts on parameters of bird physiological responses, like corticosterone (CORT), glucose and creatine kinase (CK) before slaughter [6-8] and thus has an effect on meat quality indices such as meat color and water holding capacity (WHC) [9,10]. According to these indicators, we can evaluate the stress level of poultry, so as to improve the management of transport conditions to meet the needs of poultry [6].

Overall this review is aimed to briefly introduce indices of physiological responses and meat quality of birds and to have an insight into the effects of transport duration, trailer microclimate and loading density on these indicators.

Transport Duration

Transport duration (distance) has an influence on welfare and death loss of birds. Most studies have correlated long-term transport with higher mortalities [3,11-14]. Aral et al. found that for broiler chickens transported for slaughter in Turkey, mortality rates ranged from 0.29% in journeys lasting less than 2 h to 0.46% for journeys lasting more than 10 h [11].

Concentrations of hormones, metabolites and meat color, etc. were also investigated in other studies to evaluate effects of transport time on level of stress and meat quality in birds. Transport stress can activate HPA, increasing the concentrations of blood CORT of broilers [8,15]. Interestingly, a 3 h recovery after transport could facilitate plasma CORT to return to its normal level [16]. Generally, transport stress can decrease lymphocyte quantity and meanwhile increase numbers of heterophils, leading to an elevation on the heterophil:lymphocyte (H:L) ratio [17]. Consequently, the increasing of HL ratio is a reliable and steady parameter reflecting poultry transport stress [6,18,19]. Transport duration could considerably affect plasma glucose level [16,20-22]. Zhang et al. reported that blood glucose increased for short time transport, which was supplied by liver glycogen and a 3 h transport could decrease plasma glucose level, because of the exhaustion of liver glycogen [16]. Similar reductions of glucose following long transport duration were also found by Suchy et al., Sarkar et al. and Vosmerova et al. [20,21,23]. When the breakdown of liver glycogen could not make up for the shortage of glucose, animal body initiates the use of fat and protein. Non-esterified fatty acid (NEFA) is a good indicator of lipolysis. Nijdam et al. reported that blood NEFA level was raised in broilers suffering transport with feed withdrawal compared with those have access to food and also found

that the combination of feed withdrawal and transport consumed more energy of broilers [8]. Besides that plasma uric acid (UA) is a major antioxidant and the primary end product of nitrogen metabolism in poultry, and it is an indicator of oxidative stress and tubular function of the kidney [24]. Huff et al. reported that transport caused a significant increase in turkey plasma UA concentration, indicating a negative energy balance [25]. Creatine kinase (CK) is an intracellular enzyme and its increasing activity is caused by damage to muscle membrane integrity related to stress [7]. The release of CK occurred in ducks following a 2 h transport [26]. Moreover, the increasing concentrations of plasma total protein and albumin are utilized to measure the dehydration of poultry following long time transport. Total protein and albumin levels increased in ducklings due to the 4, 8 and 12 h of the transport [18].

Meat pH and water holding capacity (WHC) are two of the most common parameters for assessing meat quality of poultry. WHC, the ability to keep innate water, is a key property of meat for its influence on meat quality and further processing. In poultry, drip loss is a more frequently used method for WHC. Poultry meat with low pHu (ultimate pH) is related with low WHC, which can alter the color and texture, ultimately affecting consumers' acceptance [27]. Debut et al. stated that if birds were transported for 2 h, the thigh meat showed darker color, high pH and higher curing cooking yield, but transport has no major adverse effect on the breast meat quality [28]. Ducks breast muscle pH 10 min (10 min post-mortem pH) after slaughter was significantly lower after a 2 h transport and reduced muscle quality is also disadvantageous for the duck industry [26]. However, Fernandez et al. gave the results that 30 or 150 min transport duration had little influence on muscle pH 20 min and pH 24 h [29]. The contrasting reports of meat quality could be explained by the not unified measurement methods (different device, measuring time or muscle, etc.) used in experiments and the various transport time, which can influence the results of meat quality after transport.

Furthermore, transport could affect broilers muscle glycogen contents and thus impact on meat quality. A 3 h transport decreased glycogen contents with an increase in lactate content in broilers breast muscle, accompanied with lower pH 24 h and higher drip loss, so transport induced negative changes on broiler breast meat quality could result from the glycolytic enhancement [30]. Savenije et al., Owens et al. and Debut et al. also found the similar results of glycogen contents in birds breast muscle [10,28,31]. However, the increasing transport time decreased the glycogen content of biceps femoris muscle, while that of the breast muscle did not change, possibly since the thigh muscle is involved in maintaining balance in the moving vehicle during transport [32].

Trailer Microclimate

Poultry welfare during transport is most importantly affected by trailer microclimate which includes heat stress (due to high temperature and humidity) and cold stress (due to cold air and wet feathers) and they are the two major reasons for both higher mortality and transport stress [33-36].

A lot of previous work has been done in Europe and thus focuses on heat stress of poultry during transport under medium or high temperature [6,7,15,37,38]. Heat stress during transport increased blood pH and decreased pCO_2 (partial pressure of carbon dioxide) because respiratory over ventilation causes higher emission of carbon dioxide and consequently raises blood pH level [6]. Furthermore, mediated by the stress mechanism, parameters of stress responses and metabolism, such as CORT, HL, glucose and CK, are varied with the magnitude of the heat load upon the birds [7,15,37,38]. Most research studies have shown acute or seasonal heat stress can result in the declines in pH and WHC and also an increase in lightness of poultry meat [39-41].

In recent years, some researchers noticed transport under extremely cold temperature with poor ventilation inside the trailers. Knezacek et al. reported that at the crate temperature of 17.7 to 55.2°C above than environmental temperature in winter with poor ventilation, broilers experienced both heat stress that occurred in insufficiently ventilated area and cold stress nearby air inlets [42]. However, very little is known about how cold ambient temperature impacts on poultry welfare during transport [43]. Dadgar et al. found that the exposure temperature below 0°C negatively influenced meat quality, such as higher pHu and WHC and darker color, which increased the opportunities of the dark, firm, dry (DFD) meat occurrence [44]. Dadgar et al. also found that 5 and 6 week old broilers were transported at temperatures below −8°C and −14°C during winter, which caused harm effects on meat quality, respectively [45].

Loading Density

High loading density of the trailer could cause heat stress and higher death loss in birds [3,4,46,47]. Mostly during hot climates, more than seven birds per crate can increase the mortality rate [46]. Optimal loading density has an active effect on thermoregulation for transported poultry. However, optimal loading density for poultry transport has not been determined yet, because the effects of loading density are influenced by many factors, for example, the ambient temperature, trailer ventilation, bird size and the position of the drawer within a loaded truck [5,42,47,48]. Lower density means that there are more opportunities for the poultry to regulate body temperatures behaviorally, but too much space per animal may take longer time to load, cost more transport fee, and increase the risk of physical collisions and mechanical bruise [31,49].

Despite of these considerations, there is a little information about effects of different loading densities on physiological responses and meat quality. Delezie et al. reported that transport at high densities resulted in the increasing concentrations of plasma CORT, UA and NEFA, and a decrease of plasma triglyceride concentration, which suggests that the high loading densities caused high stress level and more energy consumption of broilers [15,49,50].

Conclusion

Transport stress is a common issue facing poultry industry today, as it can affect welfare and mortality of birds. This paper summarized the effects of transport duration, trailer microclimate and loading density on physiological responses and meat quality of poultry. Based on this paper, there are two suggestions: (1) The contradictory results of meat quality after transport could be explained by the varied measurement methods and different conditions of application. (2) More future studies need to focus on the effects of loading density and transport under cold temperature on welfare and meat quality of birds.

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