

Adherence of meat to bone in chickens: First biochemical and biomechanical results.

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The quality of the attachment of meat to bone is often reported to be insufficient for more and more poultry's consumers. This is particularly true for thigh meat in broilers. The aim of this study was to compare muscle to bone attaches (namely tendons) from a biomechanical and a biochemical point of view in 25 standards broilers (6 weeks old) and 25 Label Rouge carcasses (12 weeks old). Carcasses weighted around 1.7 kg in the two groups. Various tendons (from thighs) were harvested and proceed for passive stretch tests, prior to cooking or not, in order to determine main mechanical characteristics (maximum load, stiffness, longitudinal strain). Biochemical parameters such as dry matter percentage, total collagen content, collagen solubility and sulphated glucosaminoglycans (sGAG) content were also determined. Results showed that biomechanical values differ largely from one tendon to another. These values are also different between the two groups of chickens mainly after cooking. The results clearly show that, after cooking, the adherence of meat to bone is better in Label rouge than in Standard chickens. From a biochemical point of view, significant differences were recorded between the two groups of animals for total collagen and sGAG contents and for collagen solubility. Label rouge chickens were reported to have higher collagen and sGAG contents associated to a lower collagen solubility. These differences may explain sensory differences observed for the two types of meat and could be due to increased age and/or physical activity of Label rouge chickens.

Keywords: meat-bone adherence; tendon; biomechanics; biochemistry.

Introduction

More and more consumers and poultry meat processors report a decrease in the adherence of meat to bone. This is particularly obvious after cooking and for whole members part such as thigh-leg in chickens. For several consumers this lower adherence of the meat to bone is clearly associated with a poor quality of the product. The origin of this defect is supposed to be a fast growth rate, a young age at slaughtering and/or insufficient physical activities. These characteristics seem to point out the modern broilers because they are from very fast growing lines, they are reared at a high density level and killed more and more younger. On the opposite, the French Label Rouge (LR) system impose the use of slow growing lines, a given age at slaughtering and access to free range during a large part of the rearing period. Consumer's satisfaction surveys report that meat to bone adhesion problems are rarely present in LR poultry products.

The aim of this work was to investigate biomechanical measures onto tendons from chickens in order to determine if some objective differences exist between commercial and standard and LR chickens. Some simple biochemical determination were also performed to better understand the origins of the biomechanical differences.

Material and methods

50 slow growing chickens (Label Rouge line) and 50 standard broilers, aged of 82 and 41 days old respectively, were conventionally slaughtered in a poultry slaughterhouse and immediately stored at +4° C for 24 h. Within a day, all the carcasses were dissected and the two thigh-leg parts of the carcasses were weighed, vacuum packaged and kept at - 20°C until analysis. After an overnight thawing at 4°C, the *Gastrocnemius* (Gas), the *Biceps femoris* (BF), the *Extensor Digitorus Longus* (EDL) and the *Tibialis Cranialis* (TC) tendons were precisely dissected from carcasses and immediately immersed in physiological serum to avoid severe dehydration. For each animal, one tendon was first used for performing biomechanical tests (tensile test, see below) and then frozen until biochemical analysis. Same measurements were also performed after cooking of the second tendon (previously vacuum packaged) in a 80° C water-bath for 5 min. Passive stretch (or tensile) tests were performed with a universal testing machine (MTS, Synergie 200) driven by Testworks 4.0 software.. From the collected data, the software allowed us to measure the following parameters: maximum load (in N), energy at maximum load (in N*mm), stiffness value during the elastic elongation (in N/mm) and elongation (or ΔL in mm) of the tendon at the maximum load. The initial length (L_0 in mm) of the tendon was recorded before the beginning of the test and the longitudinal strain was

calculated as $= \Delta L / L_0$. Immediately after the tensile test, parts of the tendon were removed from jaws, weighed (fresh weight in g), frozen and finally stored at -20°C until biochemical analysis.

The dry matter content was determined at 103°C for 24h. Total collagen content was determined according to Woessner (1961). The soluble fraction of the collagen was determined according to Snowden and Weidemann (1978). Samples were first heated in a buffer (0.14 M NaCl, 0.01 M H_3PO_4 , pH 7) for 10 minutes at 85°C . Then the fraction of collagen solubilized by heating was recovered after a centrifugation at 4000g for 30 min. Pellets were submitted to enzyme (Pronase E from Sigma) digestion for 16h at 20°C . The solubilized products were collected in supernatant after a centrifugation at 80.000 g for 30 min. OH-Pro content in the different collected fractions was determined according to Woessner (1961). Solubility of collagen was expressed as the percentage of soluble collagen extracted from total collagen after the pronase digestion.

After complete digestion of the tissue with Pronase E (72 h at 37°C under agitation in phosphate buffer), sGag content was determined according to the recommendations of the manufacturer (Biocolor Ltd, UK) of the BlyscanTM Sulphated Glucosaminoglycans Assay.

All the data compared values between the two groups of animal by using the GLM procedure of SAS (SAS, 2004).

Results and discussion

Biomechanical values obtain with the different used tendons are presented in the table 1. Independently from the state (raw or cooked) or the type of birds, we observed that there is a large heterogeneity in biomechanical values between tendons. This indicates that the physiological function is very important to determine if the tendons will present high (as in Gas or Edl) or low (as in BF) biomechanical values. Because all the studied tendons are coming from the thigh or the leg of the chicken, we can imagine that all of them are required for walking or standing up but they are solicited in the same manner. When the comparison of the two types of birds is made for raw tendons, it appears that Fmax values, stiffness and energy values from the label chickens are higher or not different from those of the standard birds. This indicates that tendons from Label birds are at least as, or more, resistant to stretching than those coming from standard birds. These data also indicate that Label birds present tendons which are stronger than those from broilers. On the other hand, we can observe that longitudinal strain values are generally higher in standard than in label birds. This indicates that tendons from broilers are more disposed to lengthen when they are stretched.

After cooking, all the recorded values generally dramatically fall down. This indicates that heating has largely decrease the biomechanical values of the different tendons. In most tendons, recorded values are significantly higher in label than in standards. This indicates that tendons of Label better support cooking than tendons of Standards and this may explain the general observation made by consumers who report a better adherence of meat to bone in traditional poultry productions.

Table 1 : Biomechanical parameters in various tendons from the two types of birds (n=25). Values are means \pm SD.

Tendon	Values	State*	Label	Standard	p
GAS	Fmax (N)	R	130.9 \pm 45.5	128.7 \pm 30.3	NS
		C	25.7 \pm 10.7	14.9 \pm 7.6	***
	Stiffness (N/mm)	R	26.7 \pm 9.9	23.5 \pm 6.1	NS
		C	7.1 \pm 3.0	4.0 \pm 1.7	***
	Energy. (N*mm)	R	677.6 \pm 605.5	633.6 \pm 386.5	NS
		C	61.9 \pm 28.1	37.3 \pm 31	***
	Longitudinal Strain	R	0.26 \pm 0.17	0.38 \pm 0.21	*
		C	0.72 \pm 0.37	0.61 \pm 0.42	NS
TC	Fmax (N)	R	80.4 \pm 27.8	68.4 \pm 17.8	**
		C	41.9 \pm 16.7	37.5 \pm 13.3	*
	Stiffness (N/mm)	R	36.96 \pm 11.08	24.36 \pm 7.67	***
		C	11.2 \pm 4.4	10.2 \pm 4.0	NS
	Energy. (N*mm)	R	103.3 \pm 70.4	130.8 \pm 55	NS
		C	93.7 \pm 50.5	79.9 \pm 36.6	*
	Longitudinal Strain	R	0.13 \pm 0.06	0.44 \pm 0.18	***
		C	1.03 \pm 0.91	1.28 \pm 0.84	NS
BF	Fmax (N)	R	39.11 \pm 14.54	43.33 \pm 11.89	NS
		C	49.6 \pm 29.4	17.97 \pm 8.1	***
	Stiffness (N/mm)	R	16.5 \pm 5.4	13.4 \pm 4.8	*
		C	10.5 \pm 4.5	5.7 \pm 1.9	***
	Energy. (N*mm)	R	64.5 \pm 34.7	109.2 \pm 48.8	***
		C	159 \pm 145.4	33.4 \pm 23.9	***
	Longitudinal Strain	R	0.39 \pm 0.19	0.97 \pm 0.61	***
		C	3.4 \pm 2.89	1.53 \pm 1.46	**
EDL	Fmax (N)	R	175.2 \pm 41.8	143.1 \pm 33.3	***
		C	4.4 \pm 3	5.3 \pm 3.7	NS
	Stiffness (N/mm)	R	30.9 \pm 8.1	32.6 \pm 11.3	NS
		C	1.5 \pm 1.5	4.0 \pm 4.7	*
	Energy. (N*mm)	R	653 \pm 252.2	433.9 \pm 200.4	***
		C	8.4 \pm 6.9	9.01 \pm 10.7	NS
	Longitudinal Strain	R	0.13 \pm 0.05	0.17 \pm 0.18	NS
		C	0.09 \pm 0.07	0.07 \pm 0.06	NS

*: R =Raw, C= Cooked.

The biochemical values reported in the Table 2 indicates that the weight of the Gas tendon is similar in the two types of birds, probably because the animals were compared at the same body weight. Nevertheless, label birds contained more non-aqueous matter and particularly more collagen (+ 20%) and more sGag (+ 25%). Moreover, the total solubility of the collagen is less important in Labels than in Standards (-12%) which may explain a more stretchiness of the tendons of the standards broilers. Collagen and sGag are very important to maintain the cohesion and the global structure of tendon but the differences observed between the two types of birds failed to explain the lack of difference between biomechanical values of raw tendons. On the contrary, after cooking, we supposed that tendons from label birds remain stronger probably because they have better resist to heat. Others measurements (data not shown) showed that cooking (10 min at 85°C) is not able to solubilize the collagen of the tendon and we must then evoke the role of sGag to explain the decrease of biomechanical values in cooked tendons. sGag mainly serve as a physical link between fibrous of collagen but also fix a large quantity of water (due to their very polar structure) for ensuring a good visco-elasticity of the tendon. As a consequence, if the total sGag content increase in a tendon, it will retain more water, have a better resistance to dehydration and by the way a better tolerance to heat during cooking. To resume, it seems that the higher content in collagen, associated with a lower water-solubility and a higher sGag content allow Gas tendon from Label birds to better resist to cooking and therefore to present higher biomechanical values.

Table 2 : Biochemical parameters in the Gas tendon from the two types of birds (n=25). Values are means \pm SD.

Values	Label	Standard	P
Weight (g)	0.73 \pm 0.13	0.74 \pm 0.11	NS
Dry matter (% W)	32.16 \pm 2.37	26.14 \pm 2.19	***
Collagen (% DM)	73.73 \pm 6.56	65.63 \pm 5.91	***
Solubility (%)	67.61 \pm 12.25	76.18 \pm 12.41	***
sGAG (% DM)	2.68 \pm 0.63	1.98 \pm 0.64	***

Buchanan and Marsh (2002) and Yoon et al. (2003) reported that exercise modifies the biochemical content of chicken tendons as age did according to Butzow and Eichhorn (1968) or Daniëlssen and Andreassen (1988). In the present study, due to their different way of production, standards broilers and Label Rouge chickens differed largely for these two points and further experiments will be needed to know which of these two

factors is the most important to determine the adherence of meat to bone in poultry.

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