Evaluation of ratite skinning force in order to fix plant and mechanical solutions

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Drawing-force,
Ostrich slaughtering,
Skinning machines.

Summary
The skin is the most requested product of ratite slaughter and 'first-rate' ratite's skin has a high economic market. Ostrich hide is tanned in South Africa and sold all over the world. Besides, the ostrich meat is considered a niche production in the marketplace, thus allowing for another profit for the ostrich breeding. Theorical analysis of skinning process has been carried out, and an automatic measurement system has been designed to record the drawing-force on the animal's body during skinning tests. The aim of this study was to indentify the best animal position and provide values of drawing-force in order to design a specific machine for ostrich skinning. Experimental results partially confirm the proposed analysis. They point out that the angle of inclination of drawing-force with back-line mostly influences the value of drawing-force and that this influence tends to increase as the angle is near to 90° or exceeds this limit. In any case, the applied drawing-force must not exceed 350.0 daN. Therefore, with respect to their anatomy structure and the tensile strenght of the hide, ostrich skinning should be done with vertical-drawing machines and the animal should be suspended by its wings at the rail. In case of low working capacity (8-10 heads per hour), given the difficoulties highlighted during the experiments run in this study, the animal should be skinned suspended by the legs.

Valutazione della forza di strappo nella scuoiatura dello struzzo per la definizione di soluzioni meccaniche e impiantistiche

Parole chiave
Forza di strappo,
Macchina scuoiatrice,
Macellazione struzzo.

Riassunto
In questo studio sono state definite le posizioni ottimali dello struzzo in fase di scuoiatura, per consentire l'applicazione della minima forza e la salvaguardia della pelle. Inoltre, sono state definite soluzioni meccaniche per macchine specifiche e per l'adattamento di scuoiatrici per grossi capi. Dopo aver effettuato un'analisi teorica, è stata studiata una catena di misura per registrare automaticamente la forza per far avvenire il distacco della pelle dal corpo dell'animale in tutta la zona del dorso. I risultati sperimentali confermano parzialmente l'analisi teorica, evidenziando che la forza di strappo tende ad aumentare con l'angolo formato dalla forza stessa con la linea del corpo, fino a valori di quest'angolo uguali o superiori a 90°. In ogni caso, la forza di strappo applicata non è mai risultata superiore a 350,0 daN. Per applicare i valori minimi della forza di strappo, la scuoiatura dei ratiti dovrebbe essere svolta con macchine a strappo verticale e l'animale sospeso per le ali, in relazione alla struttura anatomica ed alla disposizione geometrica del corpo. Nel caso di ridotte capacità di lavoro (8-10 capi/h) si può effettuare la scuoiatura con l'animale agganciato per le zampe, viste le difficoltà operative dovute alla rotazione dell'animale, specie in linee per bovini.

Introduction

Currently, skin is the most in demand product of the ratite slaughter may be located. The longest of the animal feathers (present on the tail and the wings of male and female) are also of commercial value as they are requested by the fashion industry, while short feathers are used in the production of anti-static feather duster (Hole and Morris 1995).

The wholesale price of ostrich meat (about 25 kg/head of prime) is around 7.50 €/kg, the sub-prime (throat, neck, and nerves: about 10 kg/head) does not meet commercial interest. The average size required by the market is at least 1.3 m^2 (Raleich and Hendrickson 1994). The entire skin is valued at about € 60 and its value is decreased by the presence of scars that may form either during breeding, especially at a young age or during rutting, or from deterioration due to skinning (Benson 2000). The downgrading of the skin from the prime to the sub-prime or third choice involves a substantial depreciation of the same.

Many countries, both in and outside Europe, have been established guidelines on slaughterhouse and hygienic production of meat from ratites. In general, slaughter of ratites is possible in specific structures[1] or slaughterhouse for big animals (cattle or horses)[2], suitably adapted[3].

Skinning practices of different animals have been analysed in the relevant literature, mainly from the microbiological point of view, considering the hygiene of the skin and the carcass (Kalchayanand *et al.* 2007, Gill *et al.* 1998). The results of a microbiological research carried out during the slaughter of ostriches with different methodologies and in different systems (Tullio *et al.* 1997) showed that the slaughter on the line for sheep and goats determines higher microbial contamination on carcasses of ostriches, contrary to what is found on slaughter plant for big animals (Tullio *et al.* 1997). Other studies have shown that the reduced level of mechanization of a slaughter line and reliance on manual operations increase the bacterial charge on the skin and on the meat (Cunningham 1982).

Experimental tests on ratite slaughter were conducted in plants for sheep and cattle. The results showed that skinning is the longest and more complicated phase of the slaughter process. In an industrial plant, it should be carried out in 2 sections:

- dressing (removal of the skin from the thighs, wings, belly, and chest), and
- complete removal of the skin (Bianchi 1998).

This last operation could be carried out using a machine able to develop a force such as to remove the skin from the back of the animal without damaging the skin and without causing trauma on the meat (Bianchi 2002). Considering the anatomical conformation of the animal, the step of automatic skinning would not affect more than 50% of the skin to be removed; which is, nonetheless, the most valuable part of the skin. The remaining part must still be manually detached in dressing (Bianchi 2002).

The aim of the present study was to carry out the physical-mechanical study of ratite skinning, providing criteria for design of specific machines or for the adaptation of existing skinning machines for big animals.

Materials and methods

Theoric considerations

When the process of drawing of the hide from the ostrich's body is studied theoretically, it is necessary to distinguish 2 scenarios, which are identified

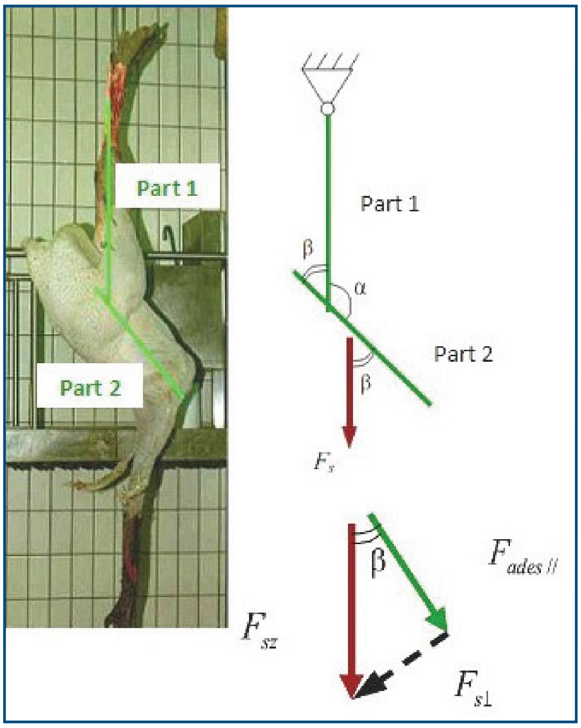

Figure 1. *Schematic representation of the application of pulling force (Fs) to the trunk of the ostrich and decomposition of the pulling force vector in two components: parallel and perpendicular to the direction of the back.*

[1] European Commission (EC). 1971. Council Directive 71/118/EEC of 15 February 1971 on health problems affecting trade in fresh poultry meat. *Off J*, **L 55/23**, 08/03/1971.

[2] European Commission (EC). 1964. Council Directive 64/433/EEC of 26 June 1964 on health problems affecting intra-Community trade in fresh meat. *Off J*, **L 212**, 29/09/1964.

[3] Circolare n. 3 del 9/3/98. Linee di indirizzo e coordinamento per la produzione e commercializzazione delle carni di uccelli corridori (ratiti) ai sensi del D.P.R. 30 dicembre 1992.

Figure 2. *Vertical skinning machine during experimental tests; ostrich suspended by the wings.*

according to how the body is suspended to the slaughtering track walking beam. Due to its particular anatomical shape, the body of an animal can be suspended either by its feet – and thus is positioned obliquely (Paleari *et al.* 1995) – or by its wings, in this case the same animal is basically positioned vertically, except for the flexible neck which falls backwards (Bianchi 2002) (Figures 1 and 2).

In order to carry out the mechanical skinning of an ostrich it is necessary to apply a downwards force superior to the adhesion force of the hide to the body. The 'pulling' force is applied in correspondence to the 2 patches of hide that have been appropriately prepared manually. During the skinning process, this force is not constant, for its intensity varies according to the position along the trunk. The variables that have an influence on this phenomenon and the applied pulling force can be difficult to evaluate in theoretical terms as shown in Table I .

The intensity of the pulling force must also be inferior to the resistance to the traction of the hide. In fact, in order to avoid its devaluation, it is of utter importance that the hide does not get damaged or torn. Therefore, in all the infinitesimal intervals z of the part of the trunk where the mechanical pulling of the hide occurs, the force must adhere to the following expression:

$$F_{a\,(z)} < F_{s\,(z)} < F_{r\,(z)} \quad \forall\, z \in back \tag{1}$$

where:

$F_{a\,(z)}$ = instant value of the adhesion force of the hide to the body, variable from point to point, along z; z is the curvilinear coordinate that follows the line of the back;

$F_{s\,(z)}$ = instant value of the pulling force in a generic application point along the curvilinear coordinate z;

$F_{r\,(z)}$ = instant value of the resistance of the hide to the traction.

A downward F_s traction is applied during the drawing of the hide, when the animal is suspended by its feet.

The pulling force can be decomposed in 2 components (Figure 1): the one parallel to the direction of the trunk (F_{sz}) and the one perpendicular to the trunk ($F_{s\perp}$):

$$F_{sz} = k \cdot \frac{F_{ades//}}{\cos\beta} \tag{2}$$

where:

F_{sz} = instant modulus of in the unit z ;

$F_{ades//}$ = component of adhesion force parallel to the body line;

k = friction value.

Then, we can obtain the mean value of the pulling force:

Table I. *Main variables that could influence the magnitude of the pulling force and the quality of the hide during skinning.*

Mechanical variables	Phisiological variables
Width of the hide size in traction	Body temperature
Inclination of the trunk	Age of the animal
Type of hinge attaching the corpse to the rail, and the work base (if present)	Quantity and quality of fat under the hide
Pulling speed	Type of feed

$$\overline{F_s} = \frac{\int F_{sz}\partial z}{z_{tot}} = \frac{\int k \cdot \frac{F_{ades\,/\,/}}{\cos\beta}\partial z}{z_{tot}} \quad (3)$$

The mentioned mean value is inferior to the value of the breakaway-force, which is equal to:

$$F_b = k_1 \cdot \frac{F_{ades\,//}}{\cos\beta} \quad (4)$$

where k_1 is the breakaway friction value $k_1 > k$.

The equation (4) is valid for any width of a part of the back, when an animal is skinned mechanically.

Similar considerations can be made when the animal to be skinned is suspended by its wings. In this case, the trunk is in an almost vertical position, the β angle diminishes compared to when the animal is suspended by its feet. The perpendicular component of the adhesion force of the hide to the back becomes negligible compared to the perpendicular component. In this way, the pulling force to be applied is lower, as the β angle nears 0, and cosβ nears 1. Therefore a lower force is necessary in order to skin a ostrich which is suspended by its wings.

Plants and machines used in the experimental tests

The experiment phase was carried out in 2 slaughtering plants:

- slaughtering plant with CEE authorization situated in Noci (Bari, Apulia, Italy), equipped with 3 separate slaughtering production lines, 1 for large animals, cattle or horses, 1 for sheep and goats, and a third one for pigs;
- slaughtering plant with CEE authorization in Conversano (Bari, Apulia, Italy), equipped with a production line for large animals and another one for pigs.

The experiments have been carried out using 2 models of skinning machines: a skinning machine with vertical pulling and a skinning machine with oblique pulling.

Skinning machines with vertical pulling

This machine is equipped with a roller motorized by a hydraulic motor (Figures 2-3; Table II). In the lower part of the machine, there are 2 feeding rollers. The oleodynamic central commanding system and the motorised roller for the rolling up of the chains are space out of about 10 cm towards the back part of the animal in working position. A mobile platform brings the workers to the right height and so to carry out the skinning along the body of the animal, which is suspended to the track walking beam. The moving of the platform is done by way of an oleodynamic piston operated by a central system and switch at low voltage. The lateral railing has 2 openings to allow for the animal to enter and exit and to prevent the workers from falling from the unprotected sides. During the working phases, workers are attached to the railing by way of the proper protection chains which are detached when the skinning is done, after which the animal can be transferred to the successive work phase.

Figure 3. *Vertical skinning machine during experimental tests; ostrich suspended by the feet.*

Table II. *Technical characteristics of the tested vertical skinning machine.*

Planning measures	2,000 mm x 1,600 mm
Double action hydraulic cylinder (stroke length)	C = 1,800 mm
Working pressure	80 bar
Rated power	P = 1.1 kW
Electric motor (hydraulic system)	P = 1.1 kW; 4 poles
Diameter of filter	D = 80 mm
Pump range	Q = 20 dm3/min
Max pressure (safety valve)	Pressure = 90 bar
Diameter of check valve	9.5 mm
Type of solenoid valve	monosolenoid
Telescoping cylinder (stroke length)	C=1,800 mm

Skinning machine with oblique pulling

In this machine the motorised roller is soldered to the lower part of the platform (Figure 4; Table III). The machine is made out of stainless steel AISI 304, with a sliding guide in high-density polizene. The oleodynamic central system consists of 2 pumps, the one with the higher capacity feeds the roller and the one with the lower capacity feeds the actuator cylinder, which is attached to the platform. In fact, the moving of the platform is controlled by the workers, who operate an oleodynamic piston controlled by the central system. Also in this case, the workers are protected, as platforms are equipped with either a bulwark with a locking mechanism, which can be stopped by way of a foot pedal, or with a safety automatic blocking system in case the hose, with fluid under pressure, ruptures.

Experimental tests

Ten clinically healthy ostriches were selected, they were between 12 and 13 months old, with a weight ranging between 70 and 80 kg, and height from 1.5 m to 1.85 m. The animals were selected at the same farm and had the same diet consisting of oats, barley and mainly fresh green grass.

In the studied plants the production lines for large animals were used, the experimental tests followed the following protocol:

Figure 4. *Oblique pulling skinning machine; ostrich suspended by the feet.*

- 2 animals skinned manually, suspended by the feet (Figure 5);
- 2 animals skinned mechanically, suspended by the feet using the oblique pulling skinning machine;
- 3 animals skinned mechanically, suspended by the wings using the vertical pulling skinning machine;
- 3 animals skinned mechanically, suspended by the feet using the vertical pulling skinning machine.

The experimental tests done with the manual skinning were conducted to obtain data that could be confronted with the results of the experiments done with mechanical skinning.

During the mechanical skinning, the employed time and the bacterial load on the carcass were measured, as well as the applied force to remove the hide from the animal's body.

A series of measurements consisting of the following components was defined to assess the pulling force:

- 2 charging cells (electronic dynamometers of strain-gage type);
- 2 amplifier modules and a signal filter;
- a terminal board SCB-68 to direct the signals from the charging cells to the computer (National Instruments);
- a system of data acquisition and its filing on a NI PCI-6052E data acquisition card installed on a PC in order to visualize and register in real time the signals sent from the charging cells. The same data acquisition card was used for the processing phase, and data analysis was run for the data concerning the time and amplitude range.

Data were acquired in a continuous succession, every 0.001 s, that is every millisecond. Therefore, an

Table III. *Technical characteristics of the tested oblique skinning machine.*

Planning measures	3,000 mm x 2,000 mm
Hydraulic cylinder (stroke length)	C = 2,000 mm
Working pressure	80 bar regolabile
Rated power	P = 11 kW
Electric motor (hydraulic system)	P = 11 kW; 4 poli
Hydraulic motor	cylinder capacity = 100 cm^3; transmission ratio = 1:19.3
Diameter of filter	D = 80 mm
Pump range	Q = 20 dm3/min
Max pressure (safety valve)	Pressure = 120 bar
Diameter non-return valve	9.5 mm
Telescoping cylinder (stroke length)	C = 1,800 mm

experiment lasting 1 minute resulted in 60 x 1,000 = 60,000 samples for every charging cell, hence 2 x 60,000 = 120,000 samples.

The signal was saved on word files and was processed with a Matlab program R2010b, so that they could be filtered with the 'smooth' function, which calculates the mobile mean value of the signal. In this way, values have been obtained which were due to interferences or disturbances, especially in high frequency. The transfer function *h (l, k)*, which performs this task, modeled by the discrete Gaussian function with 0 mean, is given by:

$$h(l,k) = ce^{-\frac{(l^2+k^2)}{2\sigma^2}}$$

where

σ is the standard deviation of the probability distribution associated,

c is the normalization factor, which in this case is assumed equal to 1 (Fischer *et al.* 2003).

Before skinning, the measuring system was tried, suspending the charging cells to the track-walking beam with the proper hooks. The computer showed the weight of the hooks and the charging cells, subsequently the de-feathered animal was suspended, to assess the total weight: the charging cells + hooks + animal. During the processing phase of the value of the total weight, the weight of the dynamometers, and of the hooks was deducted, so to calculate the actual weight of the suspended animal to the slaughtering track walking beam. After the skinning, the weight of the animal and of the hide were measured.

During the experimental tests of manual and mechanical skinning, evaluations were made on the total bacterial counts and on the quality of the hide. The aim was to evaluate possible effects of mechanical solutions on the hygiene of the meat and the commercial value of the hide.

The evaluation of the total bacterial counts (superficial distribution of the mesophilic microorganisms expressed in CFU/10 cm^2) was carried out according to the techniques suggested by Tullio and colleagues (Tullio *et al.* 1997). The samples were taken with a sterile sponge from 3 parts of the animals (abdomen, axillary skin fold, thigh skin fold) measuring 10 cm^2 each. The samples were taken to the PANALISI srl Laboratory of Conversano (Bari, Italy) for microbiological examinations.

Results

Manual skinning (as control)

The results of the tests of manual skinning, referring to the use of 2 operators, can be summarized as follows (Table IV):

- duration of skinning: 747 s/head;
- bacteria load: 75 CFU/10 cm^2;
- quality of hide: first rate.

These data confirm that this is the longest phase in the slaughtering process and, in order to achieve work capabilities exceeding 5 heads/h, skinning must be carried out with the use of specific machines. An alternative, less feasible on an industrial scale, is to realize more skinning stations, with high deployment of manpower and working-space.

Table IV. *Mean values of total working time, battery charge and quality of the hide (ratios between standard deviations and corresponding medium are contained in 10%)..*

Skinning method	Total working time (s/head)	Battery charge (before skinning) (CFU/10 cm^2)	Battery charge (after skinning) (CFU/10 cm^2)	Hide quality
Manual	747	145	75	1st rate
Oblique skinning machine (feet)	297	155	74	1st rate
Vertical skinning machine (feet)	75	140	85	1st rate
Vertical skinning machine (wings)	121	158	98	1st - 2nd rate

Table V. *Mean values of measures during tests on 'oblique skinning machine' with animal suspended by the feet (ratios between standard deviations and corresponding medium are contained in 10%).*

Skinning area	Time (s)*	Drawing-force (daN)					
		Left min. value	Left max. value	Right min. value	Right max. value	Min. total value	Max. total value
1 Thighs - hips	43	0	18	0	16	2	30
2 Lumbar area	86	3	45	1	35	5	80
3 Back area	109	16	185	12	145	32	314
4 Chest area	59	25	100	10	90	40	192

* Time calculated without breaks due to the performance of the experimental test.

Skinning machine with oblique pulling

The drawing-force required to pull the hide from the thighs is inferior to 30.0 daN and the duration is about 13% of the total time (297 seconds) (Table IV, Table V, and Figure 5). Moreover, in the lumbar area, *i.e.* ischium and hips, the required force is inferior to 80.0 daN and the duration is about 31% of the total time (Table IV, Table V, and Figure 5). The drawing-force required to pull the hide from the back area reaches an absolute maximum of 340 daN and the duration is about 36% of the total time, and the drawing-force required to pull the hide from the chest area (Table IV, Table V, Figure 5) and the neck is inferior to 192.0 daN, while the duration is about 20% of the total time.

These total values are not equally distributed, the force exercised on the right strip resulted lower than the force applied to the left strip (Table V).

At the end of the skinning process, the total bacterial counts was always below the threshold values determined by the current law (633 CFU/cm^2) and the obtained hide was always been first rate (Table IV).

Vertical pulling skinning machine with animal suspended by its feet

The measurements of the applied force taken from the left strip and right strip are similar, although an important deviation emerged at the end of phase 2 (Table VI, Figure 6).

The maximum value was reached at the end of the removal of the hide from the back area: with an average value of 236 daN (Table VI), but in 1 of the experiments the value reached 259 daN (Figure 6).

The total duration of the operation was about 70 seconds, of which 56% was taking up by the pulling of the hide of the thighs to the back area and 44% by the pulling of the hide from the chest area and the neck (Table IV, Table VI, and Figure 6). The obtained hide was always first rate and the total

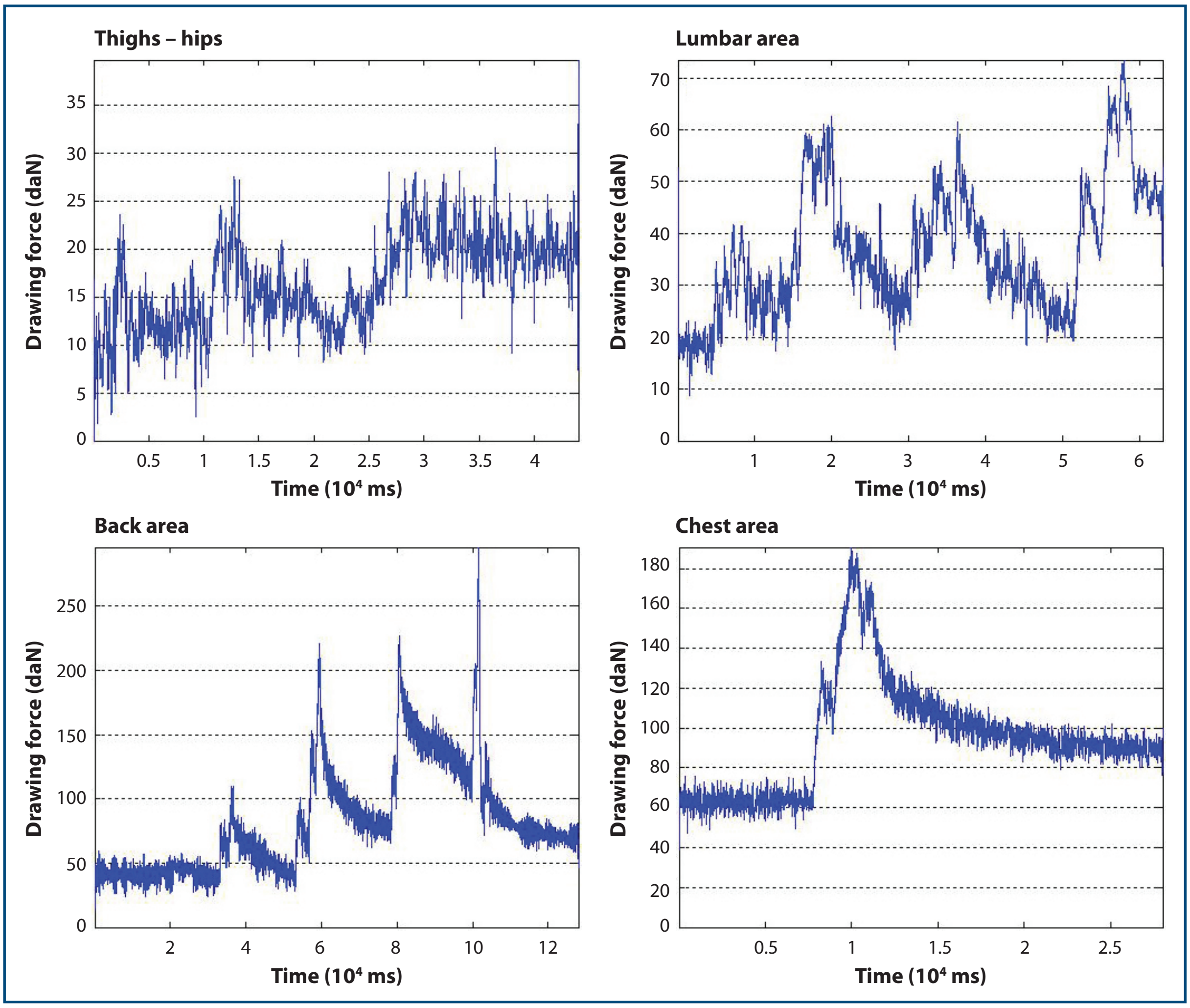

Figure 5. *Oblique pulling skinning machine: drawing force versus time during a test with ostrich suspended by the feet (mobile mean values between measures on right and left strip).*

bacterial charge was below the threshold defined by current regulation (633 CFU/cm^2) (Table IV).

Vertical pulling skinning with animal suspended by its wings

The applied force in order to pull the hide from the chest area is inferior to 165 daN and carried out by way of 'strips', reaching a value of 190 daN to about midway down the back area (Table VII, Figure 7). The applied force necessary to pull the hide of the final part of the back area reaches a maximum value of 244 daN, which is also the average value for the hips, ischium-sacral area, and feet (Table VII, Figure 7).

The total duration of the operation was about 120 seconds, of which 46% was taken up by the pulling of the hide from the chest area to about midway the back area and 44% by the pulling of the hide from the final part of the back area, hips, ischium-sacral area, and feet (Table IV, Table VII, and Figure 7).

The obtained hide was second rate (almost first rate) for the first experiment and first rate in the final 2 experiments. The total bacterial charge at the end of the skinning process resulted in being below the threshold values determined by the current law (633 CFU/cm^2), even though the recorded values were higher than the value recorded for the manual (Table IV).

Discussion

The roller of the oblique pulling skinning machine is lowered very slowly and gradually, applying periodically a very strong pulling force with a measured maximum value 20% higher than the corresponding maximum values recorded for mechanical vertical pulling skinning. The vertical pulling skinning machine not only applies inferior forces, but it also allows for skinning to be completed, on average, in half of the time required by oblique pulling skinning machines.

The higher the potency of the installed motor on the oblique pulling skinning machine, the harder it is to control the applied force deployed by the control panels installed on the machine. Therefore, the workers, after having pulled the hide tight, are often forced to stop the roller to avoid using a force which is too substantial.

The inclination of the back compared to the applied force, that is the width of the β angle, results in being one of the main variables influencing the force deployed by the machine. This correlation is, thus, more evident when the β is closer to 90°, as it

Table VI. *Mean values of measures during tests on 'vertical skinning machine' with animal suspended by the feet (ratios between standard deviations and corresponding medium are contained in 10%).*

Skinning area	Time (s)*	Drawing-force (daN)					
		Left min. value	Left max. value	Right min. value	Right max. value	Min. total value	Max. total value
1 Things - final back	42	17	145	22	157	45	236
2 Chest area - neck	33	0	61	0	94	2	131

* Time calculated without breaks due to the performance of the experimental test.

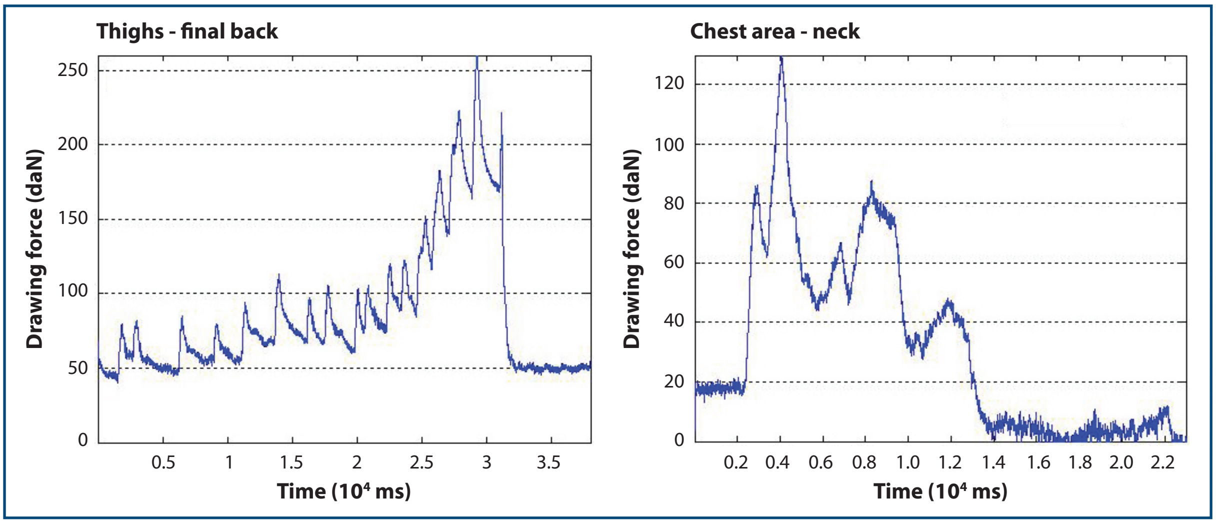

Figure 6. *Vertical pulling skinning machine: drawing force versus time during a test with ostrich suspended by the feet (mobile mean values between measures on right and left strip).*

Table VII. *Mean values of measures during tests on 'vertical sknning machine' with animal suspended by the wings (ratios between standard deviations and corresponding medium are contained in 10%).*

Skinning area	Time (s)*	Drawing-force (daN)					
		Left min. value	Left max. value	Right min. value	Right max. value	Min. total value	Max. total value
1 Neck - half back	57	14	102	15	99	41	188
2 Half back - things	64	0	110	0	138	2	244

* Time calculated without breaks due to the performance of the experimental test.

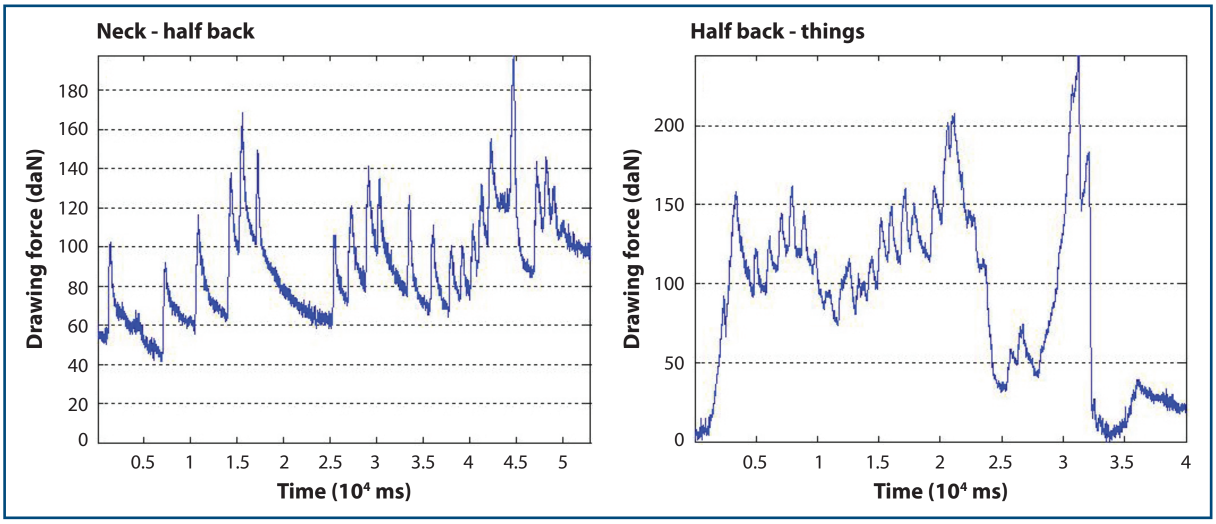

Figure 7. *Vertical pulling skinning machine: drawing force versus time during a test with ostrich suspended by the wings (mobile mean values between measures on right and left strip).*

is the case in the oblique pulling-skinning machine. The opposite is true if the β is a lot less than 90°, as is the case of ostrich suspended by feet when the vertical pulling skinning machine is used. The values of the applied force do not differ significantly when compared with those relative to the animal which is suspended by its wings, where β nears to 0. The maximum values of the applied force were measured at the lumbar area.

The applied force, when the vertical pulling skinning machine was used, resulted in being also more uniform. In fact, this type of machine has a reduced installed power, thus lower traction forces can be employed and it is easier to control the lowering of the strips of hide.

When skinning is done mechanically, another limitation is due to the difficulty of applying the same force to the 2 strips of hide. It is sufficient to have a strip longer than the other one or a chain slightly shorter than the other in order to register different forces at the same time, respectively between the left and the right. The difference between the forces tends to increase with the force itself.

Considering the mechanical results, having the ostrich suspended by the wings is the optimal position for skinning practices. With resepct to the hygiene and sanitary aspects, however, this procedure involves the highest values of the bacterial charge (Table IV). Althoutgh all values are lower than the legal threshold values (Gill *et al.* 1998, Cunningham 1982).

At the same time, previous research observes that the evisceration can be carried out more easily with the animal suspended by the wings, but this solution have some limitations. In fact, the animal suspended by the wings involves several contacts of the machine to the rotating carcass (Tullio *et al.* 1997, Bianchi 2002).

Similarly, the relatively inferior quality of the hide obtained when the animal is suspended by the wings can be attributed to problems during the preparation of the animals for the mechanical skinning, worsened by the presence of inexperienced workers.

The maximum value of the force should be at 350 daN, this would allow for removing the hide from the ostrich with a minimum damage to the hide. The applied force must be uniform and resist opposite tractions during pulling. When working with industrial skinning machines that are equipped with hydraulic systems open-circuit - as those tested in the present study - it is necessary to introduce an airfilter [with a granularity of 1-10 μm (microfine filter)], in order to prevent the introduction of dust particles in the tank.

A solution to excessive traction stress is a nitrogen oleodynamic accumulator, which reduces the impact of the first drawing force.

It can be concluded, the skinning of ratites, in relation to their anatomy structure and the hide's resistance to the drawing, should be carried out with vertical pulling machines and with the animal suspended by its wings to the track walking beam.

Given the operative-technical, ergonomic, and hygiene-sanitary limitations shown during the experimental trials (Nicolandi and Curcio 1996) for medium-low slaughtering (8-10 heads/h), the animal can also be suspended by its feet. The experiments have shown that there are technical solutions allowing for both adapting skinning machines used for cattle as well as for designing specific machines.

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