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Food Heritage: Proximate Composition Analysis of Forelegs of Steers ("Oxen") and Their Pharaonic Cultural Context

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Introduction

This early report is an example of the scientific analyses I am undertaking within the Tourism Guidance Department, Faculty of Tourism and Hotels, at Fayoum University, Fayoum, Egypt, as a part of my doctoral dissertation, "Food Heritage of Ancient and Contemporary Egypt with Particular Emphasis on Meat Products." This work aims to explore ancient Egyptian traditions and habits that remain active in Egypt today by drawing links between ancient and contemporary Egyptian cultural heritage, particularly food issues. The traditional cultural and social heritage of Egypt includes different types of meat and meat-based products and meals, cooking traditions, and eating habits. This dissertation particularly aims to survey and describe different meats and meat-based products in Egypt, both past and present. The importance of the study also stems from its contribution to data related to the mobility of food traditions through Egyptian history, with a particular emphasis on meat products.

This present paper examines the foreleg of steers ("oxen")[1] so familiar to Egyptologists. Because most previous studies have attempted to explain only the religious importance of the foreleg, the study offered here explores another important facet of the foreleg, namely its nutritive value, to scientifically examine possible nutritional reasons for the Egyptians' selection of this specific part of the steer as an essential element in their funerary offerings.

Beef Cattle in Ancient Egypt

Throughout all periods of Egyptian history, cattle, as either wild game or domesticates,[2] have been important sources of meat and dairy products, as well as bones, horns, hooves, tendons, hides, and dung.[3] Although the Egyptians kept bulls to be sacrificed at various festivals and consumed their meat (and only occasionally slaughtered cows[4]), they preferred steer as a meat source because, besides rendering a bull less aggressive, castration increases the amount of fat the animal will develop.[5] Suggested ages for castration differ. Gilbert suggests that young bulls were castrated at the age of 9 to 12 months or perhaps a bit older,[6] while Ikram thought about a year older than this range.[7] Some traditional castration procedures (which involve cutting only the end of the scrotal sac and withdrawing the testicles through it) leave the scrotum intact; this,

Ikram proposes, may account for seemingly intact "bulls" that appear in many scenes of sacrifice or butchery.[8]

In the pharaonic period, most cattle belonged to the king, but other individuals and institutions (temples) owned them as well.[9] Beef was served to privileged members of society,[10] and to gods and the dead as offerings frequently in the form of a foreleg.[11]

Slaughter and Severing the Foreleg

The butchery process (Figs. 1–3, 6) appears represented on the walls of many tombs and temples, from the Old Kingdom (when such scenes were particularly popular) until the end of the Late Period (Table 1; Figs. 1, 6);[12] models are also known (Fig. 3).[13] The animal's legs were trussed so the team of butchers could force it to lie on the ground; a butcher then took hold of the animal's head and cut its throat.[14] Now the blood drained out[15] (and was caught, perhaps to be cooked[16]), after which the butchers may have begun to flay the carcass.[17] Butchers sometimes removed the foreleg(s) at the scapula before flaying, as evidenced by discoveries of forelegs with skin that had been deposited as, for example, foundation deposits or funerary offerings.[18] Leaving the skin intact perhaps helped the meat to last longer before spoiling and would have preserved the edibility of a burnt offering.[19] Either before or after flaying, as in modern times in Egypt, dismemberment began with the right foreleg, then the left foreleg, followed by the head and, finally, the hind legs.[20] Ikram notes that, unlike ancient butchers, modern Egyptian butchers cut the foreleg at the carpal (between the radius/ulna and the metacarpals; see Fig. 4 and Table 2, bone labeled *d*).[21]

Thoracic (i.e., fore) and pelvic (hind) limb bones have essential similarities but do differ markedly, especially in their skeletal structure. Whereas the pelvic limb features, as its uppermost element, a femur that is generally rounded in section and articulates in a ball-and-socket fashion with the hip bone,[22] the upper end of the thoracic limb (Fig. 4; Table 2) is characterized by its scapula (shoulder

Table 1: Butchery scenes at Egyptian archaeological sites (Ikram 1995, 297–303).

Site	No. of Butchery Scenes
Sakkara	76
Giza	70
Thebes	65
Abu Rawash	2
Meir	5
Sheikh Said	2
Meidum	2
Beni Hassan	5
Kom el-Hisn	1
Kom el-Ahmar	1
Zawyet el-Amwat	2
Deir el-Gebrawi	2
Deir el-Bahri	1
Asyut	1
Amarna	6
Lisht	1
el-Hammamiya	1
Naga ed-Deir	1
el-Qasr	1
Gebelein	1
el-Kab	2
Hierakonpolis	1
Elephantine	2
Aswan	1
Moalla	1
el-Bersheh	1
Deshasheh	1
Total	**257**

Figure 1: Butchery scene from the tomb of Usernetjer at Saqqara, Fifth Dynasty (from Murray 1905, pl. XXIII).

Figure 2: Butchery in modern Egypt during Eid al-Adda (photograph courtesy of Adel S. Elnabtiti).

Figure 3: Model of a slaughterhouse from the tomb of Meketre at Thebes, early Twelfth Dynasty, MMA 20.3.10, Rogers Fund and Edward S. Harkness Gift, 1920 (courtesy of the Metropolitan Museum of Art, CC0 1.0).

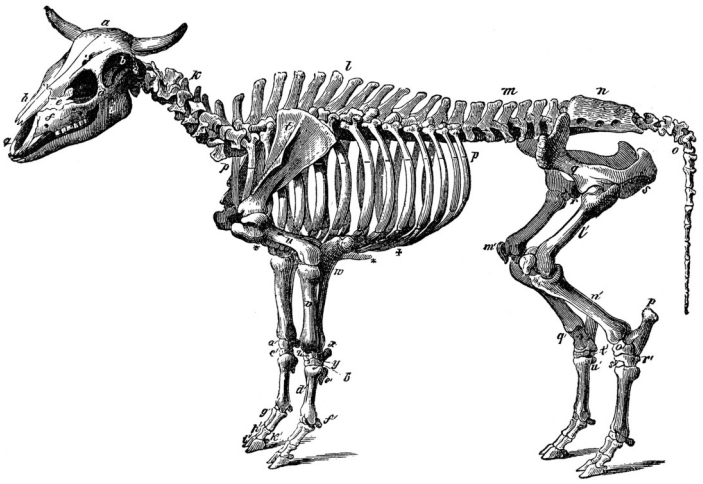


Figure 4: Bovine skeletal structure (from Vaughn 1892, 99 fig. 25).

blade), a bone that flares upward as a broad triangular form that is flat on its medial (inner) face and ridged on its lateral (outer) face.[23] The scapula articulates with the humerus, which in turn articulates with the partly fused radius and ulna, below which are the carpal, metacarpal, and digital bones.[24] In a foreleg, most of the muscle (and, thus, the meat) is found on the scapula and the humerus.[25] (See Table 2 for illustrations and ancient Egyptian terminology of the foreleg and its constituent parts.)

Ikram believed that the Egyptians hastened the blood-draining by "pumping" the foreleg, a technique attested in modern times for some parts of the Middle East, but not Egypt.[26] Furthermore, as Gilbert and Schwabe observe, "the forelimb is the *only*

musculo-skeletal assemblage that can be removed from a mammal without [...] time-consuming disarticulation of a joint or cutting of bone."[27]

A. Weigall pointed out a "cruel rite" that he made no attempt to explain, in which the leg of a living bull calf was "amputated" while its mother cow watched (Fig. 5).[28] Although S. Ikram admitted that it cannot be known with certainty whether such a rite was "actually performed," she argues that removal of foreleg from even a relatively small animal such as a calf would be difficult.[29] Gordon and Schwabe, on the other hand, disagree, siding with H. Junker's interpretation, that a living calf, "*very thoroughly restrained*," could indeed undergo such a procedure.[30] The practice of dismembering a living animal for any purpose is unacceptable in contemporary Egypt.[31]

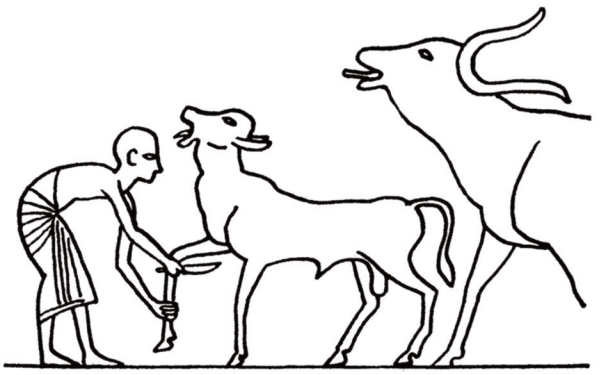
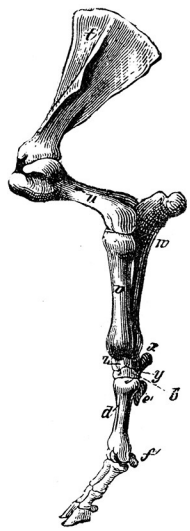
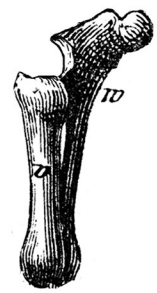


Figure 5: Relief of the amputation of a limb of a calf from the tomb of Ptahmose, Nineteenth Dynasty (Weigall 1915, 10 fig. 1).

Table 2: Ancient Egyptian terminology and anatomy of the foreleg.

English Terminology	Foreleg/Forelimb	Scapula	Humerus	Radius and Ulna	Metacarpal and Digital Bones (foot/Hoof)
Ancient Egyptian Terminology	*ḥpš* (*Wb* 3, 268; Ikram 1995, 129)	*ḏnḥ (?)* (Ikram 1995, 122–123)	*ḥpš-ḥrỉ* (Ikram 1995, 129) *ḥnḏ* (*Wb* 3, 314; Ikram 1995, 129) *tpy n ḥpš* (Ikram 1995, 129)	*ḥnḏ* (*Wb* 3, 314; Ikram 1995, 131) *ḥry ḥpš* (Ikram 1995, 131)	*ḥnd* (Wb 3, 313) *ḳbḥ* (*Wb* 5, 26; Ikram 1995, 136) *wḥmt* (*Wb* 1, 340; Ikram 1995, 136)
Figure (not to scale; adapted from Fig. 4 by Noreen Doyle)					

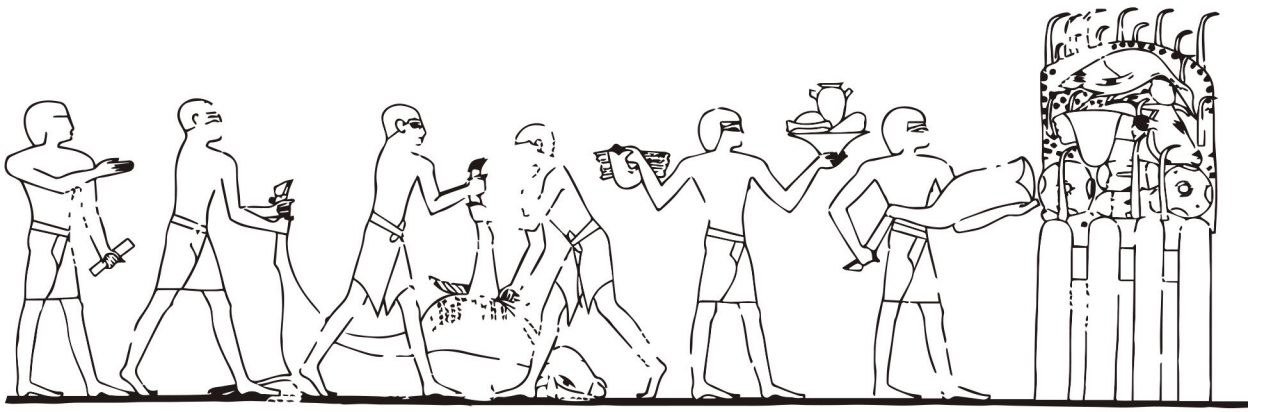


Figure 6: Butchery and presentation of the foreleg at the offering table during the funerary rites. Tomb of Rekhmire (TT 100), Eighteenth Dynasty (after Davies 1973, pl. XCII).

The Religious Importance of the Foreleg

Most scenes of steers being slaughtered are full of symbolism, as this process is undertaken as a sacred act (Fig. 6).[32] Forelegs or their parts have been found among the victuals provided to the deceased, including in burials at Thebes (Table 3), Naga ed-Deir, Tell el-Amarna, and the Memphite necropolis.[33] These were commonly placed in boxes (sometimes foreleg-shaped) before being deposited in the tomb, but unwrapped examples are known.[34]

For example, the opening-of-the-mouth ceremony, which animated either the dead or a statue, prominently featured the slaughtering of a steer.[35] This ritual presents the steer as a symbol of chaos,

Table 3: Foreleg bones found as victual mummies in Theban Tombs (Ikram 1995, 133–135, figs. 43–45).

	KV 34-35	KV 62	KV 43	KV 36	KV 46	DB 320 (Isitem-kheb)	QV 46	MMA 1021	TT 358	KV 60	Total
Scapula	12	4	0	0	1	0	0	2	0	0	19
Humerus	16	4	0	1	1	0	0	1	0	1	24
Scapula and Humerus	1	0	0	0	1	0	0	0	0	0	2
Radius	4	2	0	0	0	0	0	0	0	0	6
Radius and Ulna	14	0	0	0	0	0	0	0	0	14	28
Radius and Humerus	1	0	0	0	0	0	0	0	0	0	1
Foreleg (to carpals)	7	0	0	0	1	2	1	1	0	1	13

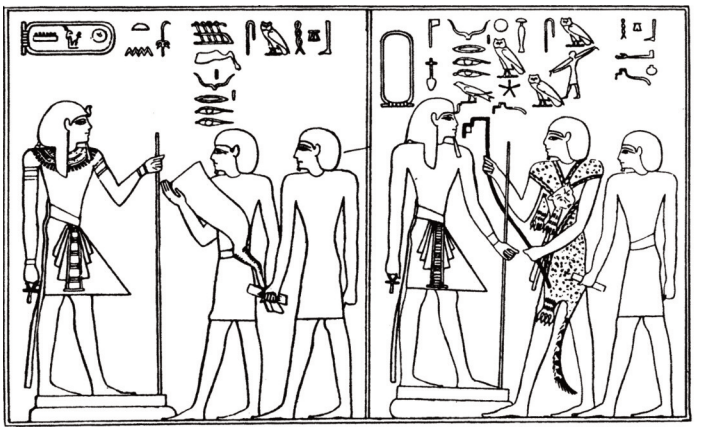


Figure 7: Two episodes in the opening-of-the-mouth ritual: foreleg (left) and adze (right) used as tools to animate a statue of the king. From the tomb of Seti I, KV 17 (Blackman 1924, 54 figs. 3-4).

Figure 8: Ursa Major/*Msḫtiw*, as a foreleg, (illustration by Noreen Doyle; photograph courtesy Moniek van Rijbroek, CC BY-NC 2.0, < https://www.flickr.com/photos/131924596@N02/20407041956 >).

enemy of both the god and the king, that is overcome by its slaughter.[36] There is another interpretation, argued by Otto,[37] that the episode of slaughtering the steer and severing its foreleg is not a (metaphorical) battle against the enemies of the king;[38] instead, it represents the final episode of a very early (Predynastic) hunting ritual once performed before a chieftain.[39] He points out that in the earliest preserved texts for the opening of the mouth ceremony date to the New Kingdom.[40] In these texts, the prehistoric ritual has become mythologized, with participants including Horus (as the butcher),[41] Thoth as a lunar god (as the slaughtered victim, who has injured Horus's eye),[42] and Isis (who, Otto argues, had no Predynastic equivalent, so she takes a role once played by a "carrion bird").[43] In the ritual, according to Otto, taking the forelimb from the steer reenacts Horus taking back his eye from Thoth.[44]

During the opening of the mouth, the foreleg was one of the tools touched to either the mummy or a statue of the deceased (or of the god) (Fig. 7, left).[45] Another tool used for this purpose was a carpenter's tool, the adze (Fig. 7, right). Since the Pyramid Texts of the Old Kingdom, both had been associated with the constellation known today as Ursa Major or the Big Dipper and, in pharaonic times, as *Msḫtiw*,[46] which is also a word used for the adze in the context of the ritual (Fig. 8).[47] As Roth has pointed out, the relative positions of the circumpolar stars (which the Egyptians identified with the netherworld[48]) and the constellation *Msḫtiw* are analogous to those of the foreleg/adze and the mummy in the opening-of-the-mouth ceremony (Fig. 5).[49] Furthermore, an interesting pattern in the orientation of the foreleg hieroglyphic sign (Gardiner Sign List F23 and F24)[50] was noted by Fischer. When it appears in texts in a context of offering, the sign is oriented with the cut thigh forward (i.e., as F24),[51] but when this sign appears in a context denoting royal strength (as in the title *nb ḫpš*), the hoof, which would deliver a

Figure 9: Cooking and serving the foreleg in modern Egypt: *fattah kawarea* (photographs by the author).

killing blow, is usually foremost (F23).[52] Roth suggests that the cut-first orientation (F24) that predominates in the sense of "offering" may also reflect the relationship between the form of the constellation and the circum-polar stars.[53]

Two particularly interesting proposals have been put forward to explain the use of the foreleg as a tool in the opening-of-the-mouth ceremony and as a prominent offering. Ikram suggests that this was inspired by its role as a "pump" to bleed the carcass.[54] Experimenting with a freshly butchered bull carcass, Gordon and Schwabe noted that muscle tremors continued in the foreleg for 15–20 minutes after it was severed, and, up to two hours later, "*contractions of whole muscles could be induced*"[55] through various forms of touch.[56] They argue that this seemingly magical phenomenon, along with the foreleg being the limb most easily removed (as previously described), inspired use of the foreleg as a ritual tool and as an offering.[57]

Preparing the Foreleg for Consumption in Ancient and Modern Egypt

Once removed from the carcass, the foreleg often appeared uncooked as an offering, but the shank (shin) was sometimes boiled.[58] To judge from the iconography, this was the most popular form of cooking beef,[59] and boiling is best method for cooking this part of the foreleg because boiling it for a long time will tenderize the meat.[60] Darby et al. report that the Terabiyin Bedouins boil their beef on the belief that it "kills evil."[61] Like the ancient Egyptians, modern Egyptians use a variety of methods to cook beef, including boiling, frying, and grilling.[62] Many Egyptians today prepare *kawarea*, shank of steer (Fig. 9), and serve it with white rice and vegetables. This meal is famous as *fateet kawarea*, an Egyptian heritage dish[63] eaten during religious festivals such as Eid El-Adha.

Proximate Composition Analysis

A proximate composition analysis of meat (or any other food) determines the presence and percentages of various general classes of substances rather than specific ones. So, for example, here the tests report the aggregate of all types of fat ("crude fat"), rather than saturated and monosaturated fat.

The Samples

Meat samples from four mature steers were obtained in Aswan Governorate in Upper Egypt (Fig. 10). Four samples were taken from butchered forelegs for evaluation of nutritive value; additionally, three samples from each were taken for histological analysis. The analyses were carried out in the Laboratory of Food Hygiene and Control, and the Department of Histology, Faculty of Veterinary Medicine, South Valley University, Qena, Egypt.

Analysis

Moisture

For the determination of moisture content, each prepared sample was dried for 4 hours in a hot-air oven at 125°C to a constant weight.[64]

Ash

A muffle furnace was used to determine the ash content using the process described by P. Cunniff.[65]

Figure 10: Meat samples taken from four mature steers in Aswan, Egypt (photographs by the author).

About 2 g of the sample was added to the porcelain crucibles, which were washed and then placed overnight in the muffle furnace (model F48010-33). The sample was cooled for 30 minutes and weighed. Crucibles were then heated over a Bunsen flame and placed in a muffle furnace at 600° C overnight until the samples turned gray. Finally, crucible and ash were placed in a desiccator to be cooled and then reweighed.

Calculation:
Ash Percentage = (Weight of Ash)/(Weight of Sample) × 100

Crude Fat

The fat was extracted using Ligugnana's method:[66] it is extracted from the sample by using petroleum ether and a Soxhlet extractor (model HMS250-4p) according to the method described by Cunniff.[67] Thus, about 2 g of the dried sample was placed onto filter paper of known weight and wrapped. Then the sample was transferred to the extraction thimble. About 250 ml of petroleum ether (boiling point, 60–80°C) was added to the boiling flask, and the heating mantle was turned on to heat the solvent. Extraction took 16 hours at a rate of 2 drops per second. Then, the sample was dried in a hot-air oven at 100º C for 30 minutes to evaporate the solvent, cooled in a desiccator, and finally reweighed.

Calculation:
Crude fat Percentage = (Weight of Fat)/(Weight of Sample) × 100

Crude Protein

Determination of the crude protein percentage in each sample was done by Kjeldahl's method using a Kjeldahl distillation unit (model VELP UDK 126 D).[68]

Digestion Procedure

1–2 g of well-mixed fresh samples were accurately weighed and transferred to a 250 ml digestion tube, to which was added one large piece of granulated zinc (to minimize pumping and prevent superheating), 7.5 g of Missouri catalyst (Kjeldahl tablets, a mixture of anhydrous potassium sulfate and copper sulfate, 9:1), and 15 ml of concentrated H_2SO^4 98%. The reaction was subsided, and the tubes were placed in a block digester. Samples were digested at 410º C for 45 minutes until the mixture became clear. When digestion was complete, the

tubes were removed and left to cool for 10 minutes. Once the tubes had cooled, 50 ml of distilled water were carefully added and the tubes were shaken.

Distillation Procedure

An Erlenmeyer flask containing 50 ml of 0.1N H_2SO_4 standard solution and a few drops of methyl red indicator was placed on the receiving platform of the distillation unit with a tube from the condenser extending below the surface of absorbing solution (sulfuric acid) to avoid ammonia losses.

The digestion tube with a fresh digested sample was placed in position in the distillation unit. 50 ml of sodium hydroxide solution (NaOH 35%) was added by the automatic dispensing device from an alkali tank of the distillation unit before distillation was conducted, and steam was distilled until 100–125 ml was collected. Then the digestion tube and receiving flask were removed from the unit.

Titration Procedure (Back Titration)

The absorbing solution was titrated against 0.1N NaOH standard solution until reaching the endpoint (the appearance of a faint yellow color).

Calculation: The amount of 0.1N NaOH consumed in titration was recorded as (R):

Nitrogen Percentage = [(50 – R)× 0.0014 × 100]/(Weight of Sample)

The protein percentage of the sample was obtained by multiplying the nitrogen percentage by 6.25, according to Jones factors.[69]

Protein Percentage = N% × 6 .25

The total carbohydrate is represented by the figure obtained by subtracting the sum of moisture, crude protein, fat, and ash of wet sample from 100 on a wet-weight basis[70] as follows:

Calculation:

Carbohydrate Percentage = 100% - (moisture % + protein % + fat % + ash %).

Table 4: Proximate composition analysis of steer foreleg samples taken at Aswan, Egypt.

Sample	Protein %	Moisture %	Ash %	Fat %	Carbo-hydrate %	Energy kJ
Steer 1	21.7	73.2	1.1	3.7	0.1	121.0
Steer 2	23.7	71.6	0.46	3.3	0.9	128.6
Steer 3	22.9	71.2	1.4	3.8	0.7	128.4
Steer 4	25.4	63.3	2.6	3.1	5.5	151.1

Energy value was calculated according to the equation given by the Food and Agriculture Organization[71] by multiplying protein, carbohydrate, and fat by factors 4, 4, and 9, respectively.

Examination of the Histological Features

Preparation of Specimens for Light Microscopy

Muscle samples were collected from different parts of the forelimb. The samples were trimmed and then excised. Samples were washed well in phosphate-buffered saline. Next, they were fixed in 4% neutral buffered formalin for 24 hours at 4° C. Samples were then dehydrated in ascending degrees of ethanol, cleared in methyl benzoate, and embedded in paraffin wax blocks. Paraffin sections (3–5 μm thickness) were stained by the following techniques.

Hematoxylin and Eosin (H&E)[72]

Harris's hematoxylin and eosin were used for general histological examination. Paraffin sections were rehydrated through graded ethanol to water, stained in hematoxylin for 1 minute, washed in tap water, stained in 1% eosin for 1 minute, washed in tap water, and then dehydrated in ethanol. Finally, samples were cleared in xylene and mounted in DPX.

Periodic Acid-Schiff's reagent (PAS)[73]

This technique was used to demonstrate stored glycogen in muscle. Paraffin sections were rehydrated through graded alcohol to water, treated with periodic acid for 10 minutes, washed in water, stained in Schiff's reagent for 20 minutes, washed in water, secondary stained in Harris's hematoxylin stain for 1 minute, washed in water, and then dehydrated in alcohol. They were then cleared in xylene and mounted in DPX.

Table 5: Proximate composition analysis of steer forelegs from Aswan with comparative samples from Ethiopia (Hawassa) and Australia.

	(Means)				
Parameter	Aswan Beef (foreleg)	Hawassa beef* (back, longissimus dorsi)	Hawassa Chevon* (back; longissimus dori)	Hawssa Mutton* (back, longissimus dorsi)	Australian Beef† (mixed cuts)
Protein %	23.3	16.1	20	19	23.2
Fat %	3.2	5.4	5.3	6.4	2.8
Moisture %	70	72.7	74.2	72.7	73.1
Ash %	1.4	1.2	0.9	1.1	—
Energy (kJ)	132.1	—	—	—	498

All data here derived from raw meat.
* Lijalem et al. 2015, 303 table 1.
† Williams 2007, S114 table 1

Results

The results showed high protein and moisture contents and low carbohydrates, as shown in Tables 4–5.

The histological section of the foreleg (Fig. 11) has striated muscles, multinucleated cells with flat and peripherally located nuclei in the sections that were stained with H&E (Fig.11a, b, c). Foreleg muscle showed strong positive reaction with PAS, indicating the presence of stored glycogen (Fig. 11c, d).

Discussion

In the current study, the paraffin sections of skeletal muscle of the forelegs showed striated, multinucleated cells with flat and peripherally located nuclei. The skeletal muscle showed a strong positive reaction with PAS due to the presence of stored glycogen, which suggests that the animals had not been subjected to significant stress prior to slaughter.[74]

The structure and protein content of meat vary by species. In this analysis, the protein percentage in meat from these steer forelegs (Tables 4–5) proved to be higher than the mean protein percentage in the beef (16.1%), chevon (goat) (20%), and mutton (19%) reported by Lijalem et al. in their samples from Hawass, Ethiopia (Table 5).[75] The current study

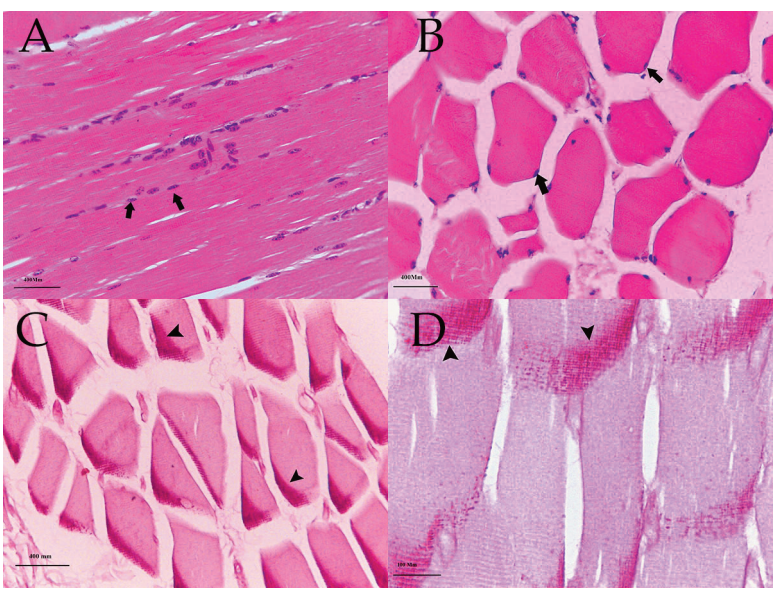


Figure 11: Histological section of forelimb, stained with H&E. a, b: nuclei; c, d: stored glycogen.

showed protein percentages similar to the mean value for a variety of cuts of Australian beef published by Williams (23.2%) (Table 5).[76]

Conclusion

It is clear that meat from the foreleg of a steer offers high protein value relative to the meat of other livestock. Perhaps the fact that cattle are one of the best sources of high-quality protein gave the ancient Egyptians an additional reason to prefer the foreleg of steer for their offerings.

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Abbreviations

Wb Erman, A., and H. Grapow, H. 1926–1961. *Das Wörterbuch der ägyptischen Sprache. Zur Geschichte eines großen wissenschaftlichen Unternehmens der Akademie*, 7 vols. Berlin.

References

Aidaros, H. 2014. "Drivers for Animal Welfare Policies in the Middle East." *Scientific and Technical Review of the Office International des Epizooties* 33.1: 85–89.

Allen, J. P. 1989. "The Cosmology of the Pyramid Texts." In Anonymous (ed.), *Religion and Philosophy in Ancient Egypt*, Yale Egyptological studies 3, 1–28. New Haven: Yale Egyptological Seminar, Department of Near Eastern Languages and Civilizations, Graduate School.

Ayad, M. F. 2004. "The Selection and Layout of the Opening of the Mouth Scenes in the Chapel of Amenirdis I at Medinet Habu." *Journal of the American Research Center in Egypt* 41, 113–133.

Baly, T. 1930. "Notes on the Ritual of Opening the Mouth." *Journal of Egyptian Archaeology* 16.3/4: 173–186.

Bancroft, J. D., and A. Stevens. 1990. *Theory and Practice of Histological Techniques*. Edinburgh: Churchill Livingstone.

Blackman, A. M. 1924. "The Rite of Opening the Mouth in Ancient Egypt and Babylonia," *Journal of Egyptian Archeology* 10.1: 47–59.

Bradley, Jr., R. L. 2010. "Moisture and Total Solids Analysis." In S. Nielsen (ed.), *Food Analysis*, 4th ed., 85–104. Boston: Springer.

Brass, M. 2013. "Revisiting a Hoary Chestnut: The Nature of Early Cattle Domestication in North-East Africa." *Sahara (Segrate)* 24: 65–70.

Brewer, D. J., D. B. Redford, and S. Redford. 1994. *Domestic Plants and Animals: The Egyptian Origins*. Warminster: Aris and Phillips.

Budras, K.-D., R. E. Habel, A. Wünsche, S. Buda, G. Jahrmärker, R. Richter, and D. Starke. 2003. *Bovine Anatomy: An Illustrated Text*. Hannover: Schlütersche.

Caminos, R. 1954. *Late Egyptian Miscellanies*. London: Oxford University Press.

Chatley, H. 1941. "Egyptian Astronomy." *Journal of Egyptian Archaeology* 26: 120–126.

Clutton-Brock, J. 1987. *A Natural History of Domesticated Mammals*. Austin: University of Texas Press.

Cunniff, P. (ed.). 1995. *Official Methods of Analysis of AOAC International*, 16th ed. 2 vols. Washington, D.C.: Association of Official Analytical Chemists.

Darby, W. J., P. Ghalioungui, and L. Grivetti. 1977. *Food: The Gift of Osiris*. 2 vols. London: Academic Press.

Davies, N. de Garis. 1973. *The Tomb of Rek-mi-Re' at Thebes*. Reprint, 2 vols. in 1. New York: Arno.

De Meyer, M., W. Van Neer, C. Peeters, and H. Willems, H. 2005–2006. "The Role of Animals in the Funerary Rites at Dayr al-Barshā." *Journal of the American Research Center in Egypt* 42: 45–71.

Demossier, M. 2016. "The Politics of Heritage in the Land of Food and Wine." In W. Logan, M. N. Craith, and U. Kockel (eds.), *A Companion to Heritage Studies*, 87–100. Malden, Mass.: Wiley Blackwell.

Faulkner, R. O. 1988. *A Concise Dictionary of Middle Egyptian*. Oxford: Griffith Institute.

Fischer, H. G. 1977. *The Orientation of Hieroglyphs* I: *Reversals*. New York.

Food and Agriculture Organization. 2003. *Food Energy—Methods of Analysis and Conversion Factors*, FAO Food and Nutrition Paper 77. Rome: Food and Agriculture Organization of the United Nations.

Gardiner, A. 1957. *Egyptian Grammar*, 3rd ed. Oxford: Griffith Institute.

Gilbert, A. 1988. "Zooarchaeological Observations on the Slaughterhouse of Meketre." *Journal of Egyptian Archaeology* 74: 69–89.

Gordon, A. H. and C. W. Schwabe. 2004. *The Quick and the Dead: Biomedical Theory in Ancient Egypt*.

Leiden/Boston: Brill/Styx.
Guilhou, N. 1993. "La mutilation rituelle du veau dans les scènes de funérailles au Nouvel Empire." *Bulletin de l'Institute français d'archéologie orientale* 93: 277–298.
Hanson, D. J., K. Kirchofer, and C. R. Calkins. 2001. "The Role of Muscle Glycogen in Dark Cuttin Beef." *Nebraska Beef Cattle Reports* 298: 109–110.
Houlihan, P. F. 1996. *The Animal World of the Pharaohs*. London: Thames and Hudson.
Howitz, W. 2000. *Official Methods of Analysis of AOAC International*, 17th ed. 2 vols. Arlington: AOAC International.
Ikram, S. 1995. *Choice Cuts: Meat Production in Ancient Egypt*. Orientalia Lovaniensia analecta 69. Leuven: Peeters.
Jones, D. B. 1931. *Factors for Converting Percentages of Nitrogen in Foods and Feeds into Percentages of Proteins*, Circular 183. Washington, D.C.: United States Department of Agriculture.
Lijalem, T., M. Beyan, and S. Banerjee. 2015. "Quality of Beef, Chevon, and Mutton at Hawassa, Southern Ethiopia." *African Journal of Food Science* 9.5: 301–306.
Mehdawy. M., and A. Hussein. A. 2010. *The Pharaoh's Kitchen: Recipes from Ancient Egypt's Enduring Food Traditions*. Cairo: American University in Cairo Press.
Murray, M. A. 1905. *Saqqara Mastabas* I. London: Bernard Quaritch.
Otto, E. 1950. "An Ancient Egyptian Hunting Ritual." *Journal of Near Eastern Studies* 9.3: 164–177.
Roth, A. M. 1993. "Fingers, Stars, and the 'Opening of the Mouth': The Nature and Function of the NTrwj-Blades." *Journal of Egyptian Archaeology* 79: 57–79.
Sadek, M. A.-S., J. R. Daoud, H. Y. Ahmed, G. M. Mosaad. 2018. "Nutritive Value and *Trans* Fatty Acid Content of Fast Foods in Qena City, Egypt." *Nutrition and Food Science* 48.3: 498–509.
Vaughn, I. 1892. *Strangeways' Veterinary Anatomy*, 4th ed. Edinburgh: Bell and Bradfute.
Wainwright, G. A. 1932. "Iron in Egypt." *Journal of Egyptian Archaeology* 18: 3–15.
Weigall, A. 1915. "An Ancient Egyptian Funeral Ceremony." *Journal of Egyptian Archaeology* 2:10–12.
Williams, P. 2007. "Nutritional Composition of Red Meat." *Nutrition and Dietetics* 64.s 4: S113–S119.

Notes

1 A castrated bull is often referred to in Egyptological literature as an "ox," but the correct term in English for such an animal, when raised for meat, is "steer." "Ox" should be reserved for cattle (either cow or castrated bull) used as a draft animal.

2 For a recent overview of the problems of domestication of cattle in Egypt, see Brass 2013.

3 Darby et al. 1977.1, 90–169, 1977.2, 758–775; Brewer et al. 1994, 77–89; Ikram 1995, 8–15; Houlihan 1996, 10–21; Gordon and Schwabe 2004, 31–45.

4 Brewer et al. 1994, 85; Ikram 1995, 12; Gordon and Schwabe 2004, 51.

5 Clutton-Brock 1987, 25; Ikram 1995, 10, 12, 44; cf. Gilbert 1988, 75–76; Gordon and Schwabe 2004, 51.

6 Gilbert 1988, 76.

7 Ikram 1995, 12.

8 Ikram 1995, 12.

9 Gilbert 1988; Ikram 1995, 10; Gordon and Schwabe 2004, 52–53.

10 Darby et al. 1977.1, 139; Brewer et al. 1994, 89. For example, the feast preparations in Papyrus Anastasi IV, 15,4 (Caminos 1954: 200); Ikram 1995, 10. For a discussion of Herodotus's claim that the Egyptians avoided eating beef, see Darby et al. 1977.1, 142–146.

11 Ikram 1995, 8, 10; Gordon and Schwabe 2004, 73–81.

12 Ikram 1995, 113, 297–303 Table I.

13 Gilbert 1988.

14 Gilbert 1988, 79, 83–85; Ikram 1995, 44–45, 46; Gilbert and Schwabe 2004, 49–51.

15 Ikram 1995, 44–45.

16 Gilbert 1988, 79–80; Ikram 1995, 47–48.

17 Ikram 1995, 48–49.

18 Ikram 1995, 51.

19 Ikram 1995, 51.

20 Ikram 1995, 116.

21 Ikram 1995, 116.

22 Budras et al. 2003, 14–15.

23 Budras et al. 2003, 2–3.

[24] Budras et al. 2003, 2–3.

[25] Ikram 1995, 125; Budras et al. 2003, 4–5.

[26] Ikram 1995, 46, 48, 116.

[27] Gordon and Schwabe 2004, 77 (emphasis in the original).

[28] Weigall 1915, 10; Ikram 1995, 50. For a mythological interpretation of this ritual with the calf as Horus and the foreleg as his hand, violated by Seth's semen, see Guilhou 1993.

[29] Ikram 1995, 50.

[30] Gordon and Schwabe 2004, 76–77, emphasis in original.

[31] See, for example, H. Aidaros 2014.

[32] Darby et al. 1977.1, 90; Ikram 1995, 42; Gordon and Schwabe 2004, 49.

[33] Ikram 1995,122–125, 129–130,136, 237–296.

[34] For unwrapped examples, see Ikram 1995, 283–296. For wrapped, see previous note.

[35] Blackman 1924, 55; Gordon and Schwabe 2004, 75–82; De Meyer et al. 2005–2006, 64–65.

[36] Otto 1950, 164; Ikram 1995, 42–43.

[37] Otto 1950.

[38] Except in a later variant (Otto 1950, 169).

[39] Otto 1950, 170.

[40] Otto 1950, 166–167.

[41] Otto 1950, 168, 171.

[42] Otto 1950, 168, 171, 175–176.

[43] Otto 1950, 166, 168–171, 176.

[44] Otto 1950, 168, 171, 176.

[45] Baly 1930; Roth 1993, 70; Ayad, 2004, 113, 117–118, 127; Gordon and Schwabe 2004, 75–82.

[46] Chatley, 1941: 120–126; Fischer, 1977: 119–127; Roth 1998 70, 76; Wainwright 1932, 8 n. 3, 11; Gordon and Schwabe 2004, 78–79.

[47] Faulkner 1988, 118; Roth 1998, 65, 70.

[48] Allen 1989, 6, 13–14; Roth 1998, 70.

[49] Roth 1998, 70.

[50] Gardiner 1957, 464.

[51] Fischer 1977, 122–124.

[52] Fischer 1977, 124–127.

[53] Roth 1998, 70 n. 57.

[54] Ikram 1995, 46.

[55] Gordon and Schwabe 2004, 80 (emphasis in original).

[56] Gordon and Schwabe 2004, 73–81.

[57] Gordon and Schwabe 2004, 81.

[58] Mehdawy and Hussein 2010, 52.

[59] Darby et al. 1977.1, 152; Brewer et al. 1994, 89.

[60] Mehdawy and Hussein 2010, 52.

[61] Darby et al. 1977.1, 152.

[62] For other methods of cooking beef in pharaonic times, see Darby et al. 1977.1, 150–159.

[63] For a discussion of food/cuisine as cultural heritage, see Demossier 2016.

[64] Sadek et al. 2018, 499–500; Bradley 2010, 88.

[65] Cunniff 1995.2, 1–4.

[66] Howitz 2000.1, 24.

[67] Cunniff 1995.2, 40–44.

[68] Cunniff 1995.2, 40–44.

[69] Jones 1931, 14-15

[70] Food and Agriculture Organization 2003, 12, 13.

[71] Food and Agriculture Organization 2003, 12, 13.

[72] Bancroft and Stevens 1990, 176.

[73] Bancroft and Stevens 1990, 222–224.

[74] Hanson 2001, 109; Lijalem et al. 2015, 304.

[75] Lijalem et al. 2015, 303 Table 1.

[76] Williams et al., 2007, S114 Table 1.