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Reviewed Article:

The Question of Fuel for Cooking in Ancient Egypt and Sudan

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Little is known about the actual cooking processes and in particular fuel-related activities in Egypt and Northern Sudan (Nubia) in antiquity, especially during the Bronze Age. Considering that wood was, in general, rare along the Nile valley and therefore an expensive raw material, animal dung was tested in 2018 by means of a series of experiments for its suitability as a fuel

for cooking in ancient Northeast Africa. Different types of herbivore dung were tried using replicas of Egyptian and Nubian cooking pots from the Second Millennium BCE. The results suggest that especially donkey and horse, but also sheep, goat, and, cattle dung provide beneficial conditions for keeping good and durable cooking temperatures while preventing fast cooling on small scale fireplaces. This seems to be especially beneficial for dishes containing legumes and cereals, which require long cooking times.

> All in all, a combined approach to the outcomes of the experiments described in this paper and of various observations and research from other regions and other periods seems very suitable for reconstructing Egyptian and Nubian domestic fireplaces of the Second Millennium BCE.

Introduction

It is well known that wood was the most important, but not the sole fuel used for activities that require the use of fire in the ancient world (Smith, 1998, pp. 191-192; see also Habermann, 2009). In particular, in regions like Northeast Africa where wood was scarce, alternative or supplementary fuels were used and a differentiation between domestic and industrial/production activities involving fire is also likely. For the Near East, animal dung is attested to have replaced wood as fuel (Smith, 1998, p. 192 with references). Similarly, animal dung "has served as fuel in rural areas of Egypt from Pharaonic times to the present" (Moens and Wetterstrom, 1988, p. 166; compare also Wilson, 1988, p. 53 for a mixture of fuel including animal dung for domestic cooking fire in ancient Egypt). For antiquity this is supported by textual records (Moens and Wetterstrom, 1988, p. 167), by archaeological, and especially by archaeobotanical evidence (for example Amarna and Kom el-Hisn, see Moens and Wetterstrom, 1988, p. 166; Smith, 1998; Gerisch, 2010).

Among the activities that require the use of fire, the question of cooking in domestic hearths in New Kingdom contexts was of concern for the ERC funded project AcrossBorders. Two major settlement sites, Elephantine in Egypt and Sai Island in Sudan, were investigated by the project, focusing on daily activities and questions of lifestyle (Budka, 2017a). The period of interest for questions related to cooking and fuel for hearths was therefore the Late Bronze Age, the Egyptian New Kingdom (circa 1550-1070 BCE). The area of interest was the Lower and Middle Nile region, in particular the area between the First and Third Cataracts. This region is characterized by diverse interactions between Egypt in the north and Nubia in the south and a complex cultural entanglement between the Egyptian culture and various Nubian groups (see, for example, Spencer, Stevens and Binder, 2017).

Different sources of evidence provide information about cooking in this region during the Second Millennium BCE. First of all, the actual cooking pots are attested and show an interesting development demonstrating interactions between the Egyptian wheel-made and the Nubian hand-made pottery tradition (Budka, 2016). Functionally relevant aspects of the

cooking vessels, such as their aperture diameter and vessel index, can provide insights into the ways in which food was prepared and consumed. Morphological changes observable during the New Kingdom, as well as of the use of a new, very sandy cooking pot fabric, are still little understood and require further research. This also applies to chemical residue analyses performed on Egyptian and Nubian cooking pots: as of yet, only nine samples from Askut in Nubia have been processed. The chemical analyses showed that the fats in the samples differ substantially, indicating a heterogeneous food production associated with the diverse cooking pot shapes (Smith, 2003, pp. 119-124); a hypothesis that needs to be tested against larger data sets.

Secondly, fireplaces and domestic hearths were documented at archaeological sites in Egypt and Nubia (Wilson, 1988, pp. 53-55). Most common are finds of charcoal in settlements which remain a bit ambiguous regarding their interpretation but are most likely connected with cooking activities (Gerisch, 2004; 2010; Cartwright and Ryan, 2017). Related to these traces of fireplaces is the general archaeobotanical evidence from towns and settlements. The last twenty years have seen great advances in the botanical analyses, of charcoal (see Gerisch, 2004) but also other micro and macroscopic evidence (Cartwright and Ryan, 2017), including analysis of seeds and legumes in botanical assemblages as possible remains from livestock implying the use of dung as fuel (Malleson, 2016; see also Moens and Wetterstrom, 1988, pp. 166-167). At Amarna, unused fuel was found in a kitchen of a New Kingdom house and identified as straw and sheep dung; cow dung cakes were also suggested for this site (Peet and Woolley, 1923, p. 64; Moens and Wetterstrom, 1988, p. 167). Wood and woody resources in Egypt (Gerisch, 2004; 2010) and northern Sudan (Cartwright, 1998; 1999; Cartwright and Ryan, 2017) are well understood and differences between firewood and timber / working wood were noted. The most common wooden fuel was Nile acacia and tamarisk in Egypt (Gerisch, 2010); while in Sudan, also much *Ficus sycomorus* was used (Cartwright and Ryan, 2017, p. 278).

Thirdly, pictorial and textual references for cooking in ancient Egypt are attested. Depictions and texts both derive from elite contexts and may refer to corresponding ideal conceptions, but should nevertheless not be ignored. For the New Kingdom, depictions of cooking activities in the context of temples and palaces are noteworthy. One scene from the royal bakeries as depicted in the tomb of Ramesses III (late New Kingdom, Wilson 1988, p. 15, fig. 12; Bresciani, et al., 1995, p. 186) can be highlighted and clearly shows wood as the main fuel for heating a fire below a cooking pot (See Figure 1). Such representations do not necessary mirror the actual lived experience and in particular fuel-related activities in non-elite contexts. However, firewood was identified as fuel for kitchens and bakeries in the Ramesseum, a major temple complex in Egypt (Tengberg, et al., 2005), supporting the corresponding pictorial evidence within royal contexts. Textual evidence derives from Egypt only and is, as yet, not available for New Kingdom Nubia. These texts are mostly ostraca and represent check-lists and accounts of materials. Ass-loads of dung, presumably used as fuel (Moens and Wetterstrom, 1988, p.

167) are attested as are ass-loads of wood sticks (Moens and Wetterstrom, 1988, p. 167) and the title “woodcutter” (Janssen, 2003) suggesting an elaborated administrative system in relation to the important raw material wood.

In general, the above mentioned supplements to firewood as fuel for cooking, water heating, and baking are indeed very likely for both Egypt and Nubia. Archaeological evidence, for example from Amarna, suggests that different types of fuel were indeed used at Egyptian sites (Gerisch, 2010, 399). This can be complemented with ethnographic parallels and ethnoarchaeological studies suggesting that specialised fuel was chosen according to function and in particular for production technology (Cartwright and Ryan, 2017, 284). For example, dung cakes are frequently attested for pottery firing, from antiquity to modern times (Zapata Peña, et al., 2003 with references). Besides technical properties, availability was an important factor for the choice of fuel and this is why ancient towns and sub-urban sites in Northeast Africa are likely to have employed animal dung since stabling of animals is well attested both within the town area, outside of city walls, and in rural places (Budka, 2017b, pp. 173-174). Precise investigations of this assumption are nevertheless lacking for the region and for the period of the Late Bronze Age. It needs to be noted that micro and macro analysis provide no conclusive evidence as to the actual use of the different fireplaces, since secondary usage and the burning of additional material cannot be ruled out. For a better understanding of the fuel application, additional analysis of the botanical surroundings of the settlements is also necessary (Cartwright and Ryan, 2017).

Ethnological comparisons from various sites illustrate that dung is frequently used as a supplement and as solitary fuel, depending on use and availability and the forms of the ovens or fireplaces (Miller, 1984). Besides advantages in the properties of the fuel and its accessibility, there are also social structures to be considered which are usually not observable in the archaeological evidence. For example, the people of the *Ouarten* tribe in Tunisia are using air-dried sheep and goat dung as main source of fuel for the daily bread production in the *tabounas* (simple oval ovens) and also for the cereal processing (Portillo, et al. 2017, pp. 134-135). Cattle and donkey dung on the other hand are used as a fresh resource for housebuilding, in particular to plaster walls and floors depending on the wealth of the families. In addition to that the ovicaprid dung is used for firing pottery. The measurement of the dung fires showed a consistent heat around 400°C, which lasted very long (still 200°C after two hours), being similar to the outcome of other analysis, like in Uzbekistan (Gur-Arieh, et al., 2013) and Syria (Portillo, et al., 2014). Examples from Iran attest to the use of different mixtures of dung and wood as fuel inside and outside the villages. The nomad campfires showed less dung than the evening campfires in the houses of *Malyan*, which were made of cattle dung cakes and additional wood supplies (Miller, 1984, p. 75).

In conclusion, the aim of the experiments which will be described in the following was to test for the first time whether the main fuel for heating cooking pots in Egyptian and Nubian

contexts during the Second Millennium BCE could potentially have been something else than wood. Alternative fuels for wood were, until today, only little discussed in this context. The tests presented here are the first experiments with dung as fuel for cooking processes from Pharaonic Egypt and ancient Sudan. For Late Antiquity in North Africa, important archaeobotanical evidence for alternative fuels to wood has already been published (Tunisia and Egypt, Smith, 1998). Samples from ovens at Kom el-Nana close to Amarna were analysed in detail. Several samples showed "remnants of large herbivore dung (possibly donkey, cow or camel)" (Smith, 1998, p. 197), raising various questions about the use of dung as fuel.

The conducted experiments 2018

The experiments described in the following were conducted by the authors on 29 and 30 June 2018 in Asparn/Zaya, Austria at the MAMUZ Museum in its open-air park. Simple fireplaces were set up using three stones to hold the cooking pot (See Figure 2); the distance of the pot's base from the ground ranged between 8 to 10cm. Temperature measurements of the cooking pot were taken using a Colemeter WT700 Infrared Thermometer and a digital Type K Thermocouple. Material surfaces as pots were measured by infrared; fire and pot filling temperatures were taken by the Thermocouple. Larger and sudden variations in the fire temperature (See Tables 1-9) may origin in inaccurate measurements as it is nearly impossible to position the probe two times in exactly the same way, and the fire itself shifts as material is consumed. Differences can also occur when the probe is held in the embers or in the flames. All temperatures as given in the tables are in °C.

Fuel

The aims for the experiments in 2018 were 1) to test alternatives for firewood as fuel for cooking with replicas of Egyptian and Nubian cooking pots since wood was rare in Northeast Africa and 2) to specify the characteristics of the much more available dung of domesticated animals such as cattle, sheep / goats, horses and donkeys. Since the experiments represent the first test series of this kind, basic data and preliminary results were expected, including possible fresh input to ask new and better questions about the processes and the division of labour connected with food processing and here in particular with fuel-related activities. In addition, it was necessary for the authors to get experience with the material tested to plan and guide future experiments accordingly. It needs to be noted that for logistical reasons, the animal dung used during this first set of experiments was not dried in the same way and exhibited different moisture (e.g. the horse dung was very dry whereas the cow dung was still very wet).

The replica cooking pots

The 2018 cooking experiments were made with modern replicas of ancient cooking pots which were produced by professional potters experienced in experimental archaeology in 2017 (Ludwig and Vera Albustin). All of these pots are hand-made, but were manufactured according to the shape and size of authentic Egyptian (wheel-made) and Nubian (hand-made)

cooking pots (Budka, 2016). The clay used for these replicas was tempered with sand and chaff and is thus similar to the original fabrics, but no exact copy of the fabric of the ancient pots (because the replicas were originally designed for a different line of experiments).

The reference cooking material

As cooking material, a reference of 250g lentils with 250ml water was used in 2018 for all experiments with dung as fuel. In order to test the actual braising qualities of the dung fires, one experiment with bulgur was undertaken (See Table 6). Most of the time, the cooking pots were covered using two different types of lids: a clay lid similar to the actual variants attested from the New Kingdom in Egypt and a vegetable variant (in our case: banana leaf), used for the Nubian cooking pot since no ceramic lids are attested for such vessels and the practice of an organic cover is therefore likely.

Results

Wood	In order to generate reliable comparative values, we initially worked with two identical firing places for an Egyptian and a Nubian cooking pot, which were fired with beech wood (See Figure 3). Regular temperature measurements in 3-5 minutes intervals over a period of 50 minutes of the fire, the pot (inside and outside wall) and the contents (the reference material) should provide us with comparative data for the following experiments with the dung. It was noticeable that our fireplaces were quite demanding—the very hard and dry wood needed constant air supply to deliver reasonably constant temperatures (about 180-300°C, see Tables 1-2). The highest temperature reached was 540°C. The cooling off process was very fast and the embers were recorded as not staying hot for very long. The contents inside the pots did not exceed 79°C (for the Nubian cooking pot, Table 1) and 67°C (for the Egyptian cooking pot, Table 2). Thus, the measurements undertaken of the temperatures of the pot and the contents over more than one hour proved rather unsuitable for cooking or even braising with such cooking fires. It is necessary to mention that the burning characteristics of the wooden fuel in ancient Egypt and Nubia, consisting predominately of Nile acacia, tamarisk and *Ficus sycomorus* (see above), but potentially also including the widely available palm wood, may substantially differ from the relative hard beech wood used during these experiments at Asparn. The wood we used had moisture of 15% (measured with a Voltcraft FM-200 Moisture Meter). Also dry bushes or brushwood have been used as fuel in antiquity (for Egypt see Wilson, 1988, p. 53) with which it would be much easier to maintain a stable hot fire.
Donkey dung	Within the experiment using donkey dung as fuel in a small fire place set up with stones (See Figure 4), temperatures were not consistent in the first trial (See Table 3). There were certainly inaccuracies during the measurement process (taking measurements from both the fire and the embers) so that the fire temperatures until minute 20 in Table 3 are not reliable. However, after this time span and once the temperature was above 200°C, the reference material was heated to around 50°C, keeping a steady temperature for 20 minutes. Another trial with donkey dung was undertaken using one replica of the so-called fire

	dogs (Budka, 2017a, p. 441) to keep the cooking pot above the fire (See Figure 5; Table 4). Both the temperature of the fire and of the content of the pot stayed very constant for more than 20 minutes. Quantity of dung used: 300g Highest temperature reached: 303°C
Horse dung	With horse dung, temperatures were consistently measured above 420°C; the reference material was heated to over 80°C within 20 minutes (See Figure 6). Similar results were achieved with a mixture of horse and donkey dung as fuel (See Table 5). These two dung kinds were the only ones which reached similar temperatures to wood. Thanks to these high temperatures, the braising of the contents was considerably fast (20-25 minutes, Table 5). This became even clearer with the successful preparation of bulgur, using a mixture of horse, donkey and sheep dung as fuel during the cooking process. Despite of a small drop in temperature of the cooking fire (See Table 6) which was based on the need for new supply of fuel, the contents in the Egyptian cooking pot were successfully prepared. The fire was supplied with dung for a period of 37 minutes; the final braising was achieved with the embers only (See Figure 7). Quantity of dung used: 250g Highest temperature reached: 480°C
Cow/cattle dung	The cattle dung employed for our test series was not yet dry and much wetter than the other dung types used for the experiments; thus, the results are most probably not reliable, but proving how difficult it is to dry the organic-rich cow dung in central European conditions (especially within days of occasionally rainy weather). Despite of that, the cow dung yielded results similar to those of the donkey dung, but with more problems during the heating phase (See Table 7). Interestingly, despite a clear drop in fire temperature, the content of the Nubian cooking pot was slowly heating up. All in all, cow dung as fuel seems as useable as donkey dung. Quantity of dung used: 150g Highest temperature reached: 320°C
Sheep / goat dung	The experiments using ovicaprid dung reached lower temperatures but stored the heat for a relatively long time. Two trials were undertaken (See Tables 8 and 9). In the first one, the temperature of the fire changed a lot, while the temperature of the content slowly and constantly increased (See Table 8). These changes in the temperature are presumably connected with the different properties of goat versus sheep dung and resulting problems in keeping a steady temperature. In the second experiment a fire dog was used to hold the cooking pot and the fire temperature was continuously around 300°C, providing stable conditions for the Nubian cooking pot and its contents (See Table 9). Quantity of dung used: 300g / 100g Highest temperature reached: 290° / 320°C

Summary

All in all, a combined approach to the outcomes of the experiments described in this paper and of various observations and research from other regions and other periods seems very

suitable for reconstructing Egyptian and Nubian domestic fireplaces of the Second Millennium BCE. Wood might have been involved in some cases, but the better availability and especially the characteristics of animal dung as fuel makes it more likely that the latter was used in domestic hearths. It was common to all types of dungs tested at Asparn that after the successful heating they provided temperatures of around 300°C for long enough that the cooking pots could be placed directly above the embers.

The dung fires provide beneficial conditions for keeping good cooking temperatures for a considerable long time while preventing the fast cooling off of the fireplaces. This seems to be especially beneficial for dishes with long cooking or braising time like legumes, porridge and cereals, and might also have been of importance for water heating.

Outlook

The basic research question addressed in this paper was whether animal dung is a suitable fuel for cooking with Egyptian and Nubian cooking pots of the New Kingdom. Despite the general positive confirmation of this assumption, more accurate statements and observations are at present not possible. To investigate the cooking process of the region and period in question further, exact copies of relevant cooking pots would be necessary (according to shape, production technique, and fabric) and cumulative series of experiments are needed. A series of tests of such authentic Nubian versus Egyptian cooking pots might generate interesting results regarding the time for heating, the cooling off process and other aspects. This could potentially illuminate questions about characteristics of pots used for braising rather than cooking. Equally relevant might be the systematic observation of traces of soot on the cooking pots which are used on fires made of wood, made of dung, and a direct comparison of these traces on the replicas and the actual cooking pots from Egypt and Sudan. Another interesting future line of research is the placement of the cooking pots above the fire and/or on the embers.

Furthermore, one kind of animal dung which was potentially of importance in Late Bronze Age Egypt and Nubia was not yet considered in the experiments. The most important animal for meat production in New Kingdom Egypt was the pig (Ikram. 1995, pp. 29-33; Bertini, 2014, pp. 306-308); dung of pigs should therefore also be included in future tests. Another aspect of possible future research is the question of composite fuel—the combined use of different fuelstuffs (Smith, 1998, p. 200), in particular of wood and dung types should be investigated regarding the temperatures and other properties.

Ethnoarchaeological work implies that in many cases there is a variation within the dung fuel used for firing purposes, for example dry dung or dung cakes are combined with fresh dung during the heating (Zapata Peña, et al., 2003, p.170). Such processes could also be tested by means of experiments. Ethnographic comparisons also suggest that it would be worth

investigating the use of dung in ancient Egypt and Sudan in connection with different housing circumstances like towns, rural villages and nomadic campsites (see above and Miller, 1984).

Finally, one may stress that experimental archaeology clearly has rich potential to address cooking processes and more general questions of the cuisine in ancient Egypt and Nubia, especially in combination with the evaluation of the botanical remains (Cartwright and Ryan, 2017) and the animal bones. Furthermore, products of livestock which are sometimes regarded as waste products only, like dung, most probably played an active role in domestic activities at New Kingdom sites in Egypt and Nubia. New lines of research like the study presented here might therefore provide additional information for reconstructing a more complete version of daily life at these places.

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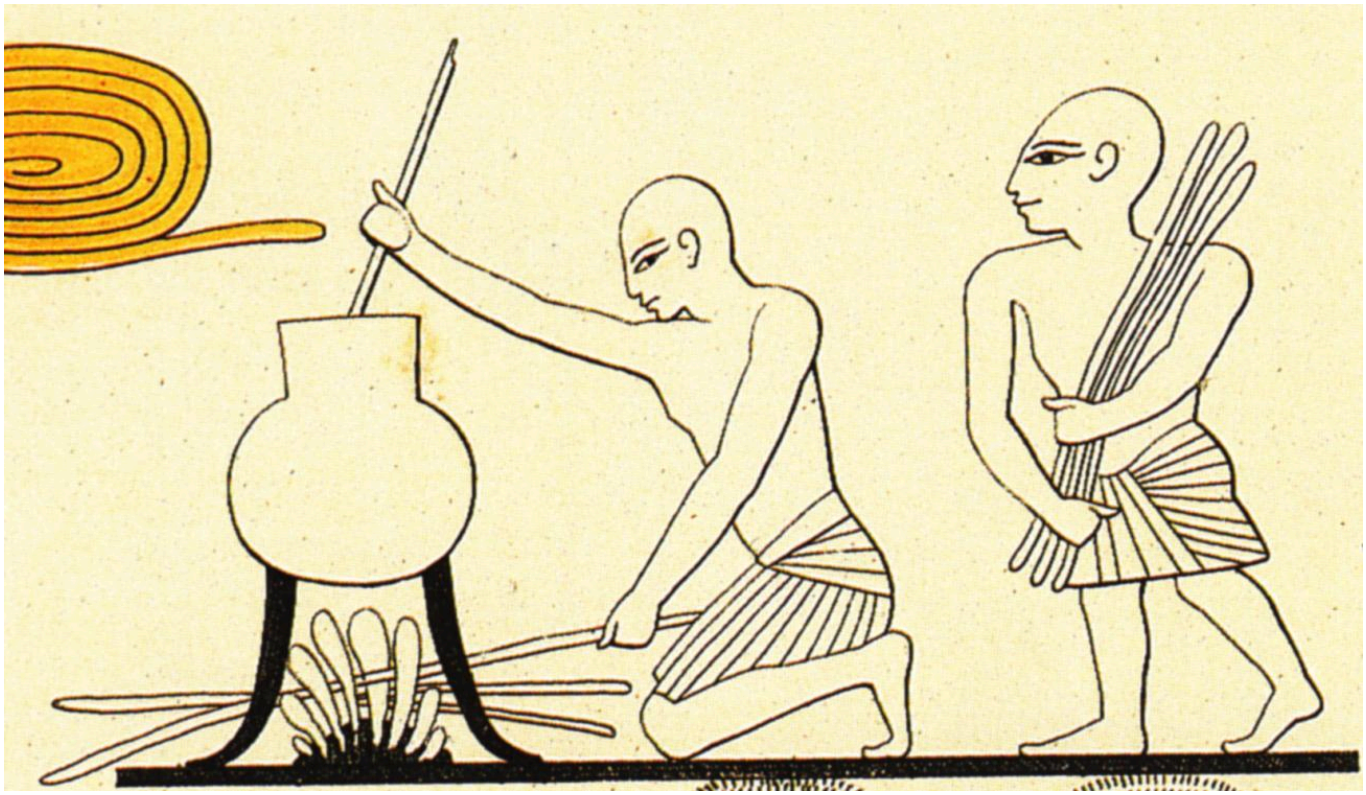

FIG 1. RELIEF FROM THE TOMB OF RAMESSES III IN THE VALLEY OF THE KINGS, THEBES SHOWING A MAN HEATING A FIRE BELOW A COOKING POT WITH WOODEN STICKS AND A SECOND MAN BRINGING MORE WOOD AS FUEL. I. ROSELLINI, M.C. PL. LXXXV, AFTER BRESCIANI ET AL., 1995, P. 186.

FIG 2. SET UP OF FIREPLACES USED FOR THE EXPERIMENTS WITH ANIMAL DUNG AS FUEL. NUBIAN STYLE COOKING POT REPLICA TO THE LEFT, EGYPTIAN COOKING POT REPLICA TO THE RIGHT. PHOTO: C. GEIGER.

FIG 3. TWO FIREPLACES SET UP WITH STONES AND FIRED WITH WOOD. PHOTO: C. GEIGER.

FIG 4. FIREPLACE WITH EGYPTIAN COOKING POT REPLICA USING DONKEY DUNG AS FUEL. PHOTO: J. BUDKA.

FIG 5. EGYPTIAN COOKING POT REPLICA PLACED ON ONE FIRE DOG, WITH DONKEY DUNG AS FUEL. PHOTO: J. BUDKA.

FIG 6. FIREPLACE WITH EGYPTIAN COOKING POT REPLICA USING HORSE DUNG AS FUEL. PHOTO: J. BUDKA.

FIG 7. SUCCESSFUL PREPARATION OF BULGUR WITH EGYPTIAN COOKING POT REPLICA USING A MIXTURE OF ANIMAL DUNG AS FUEL. PHOTO: J. BUDKA.

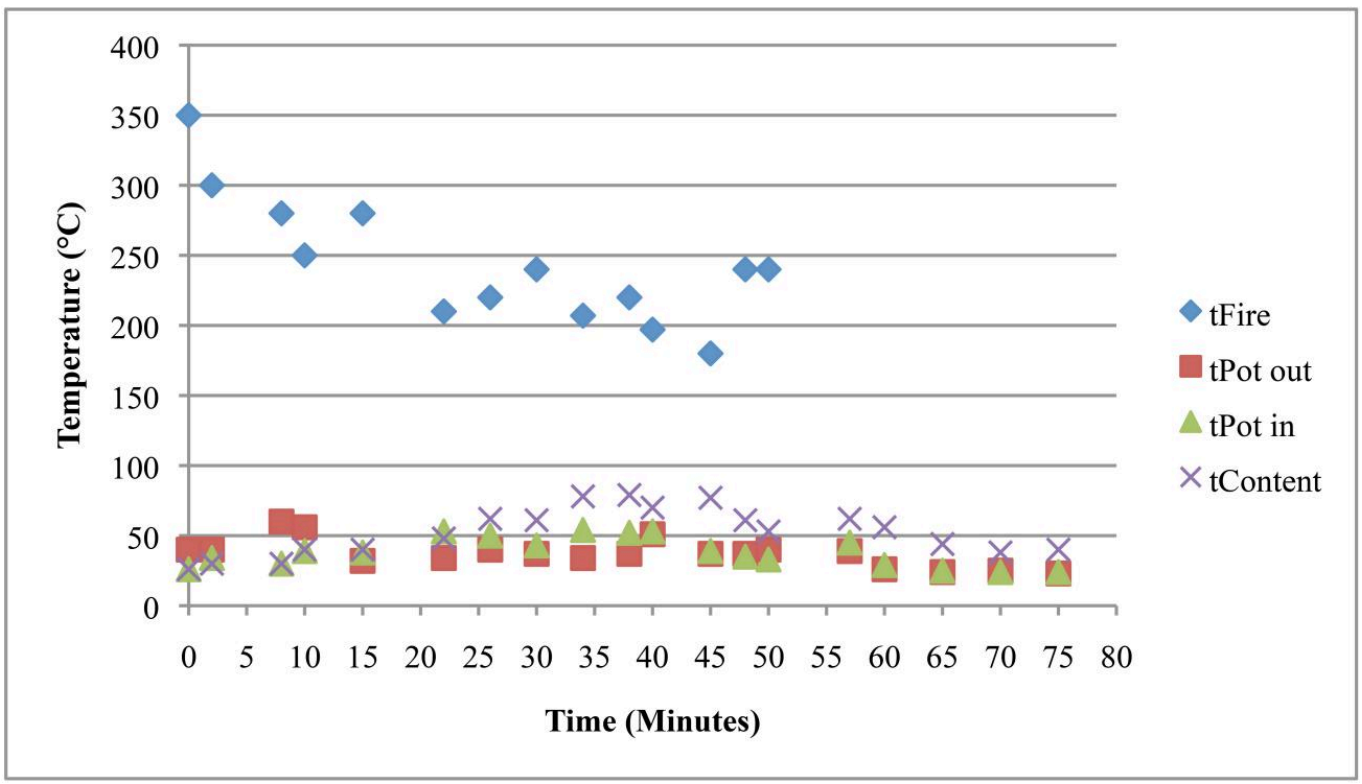

TABLE 1. NUBIAN COOKING POT ON WOOD FIRE.

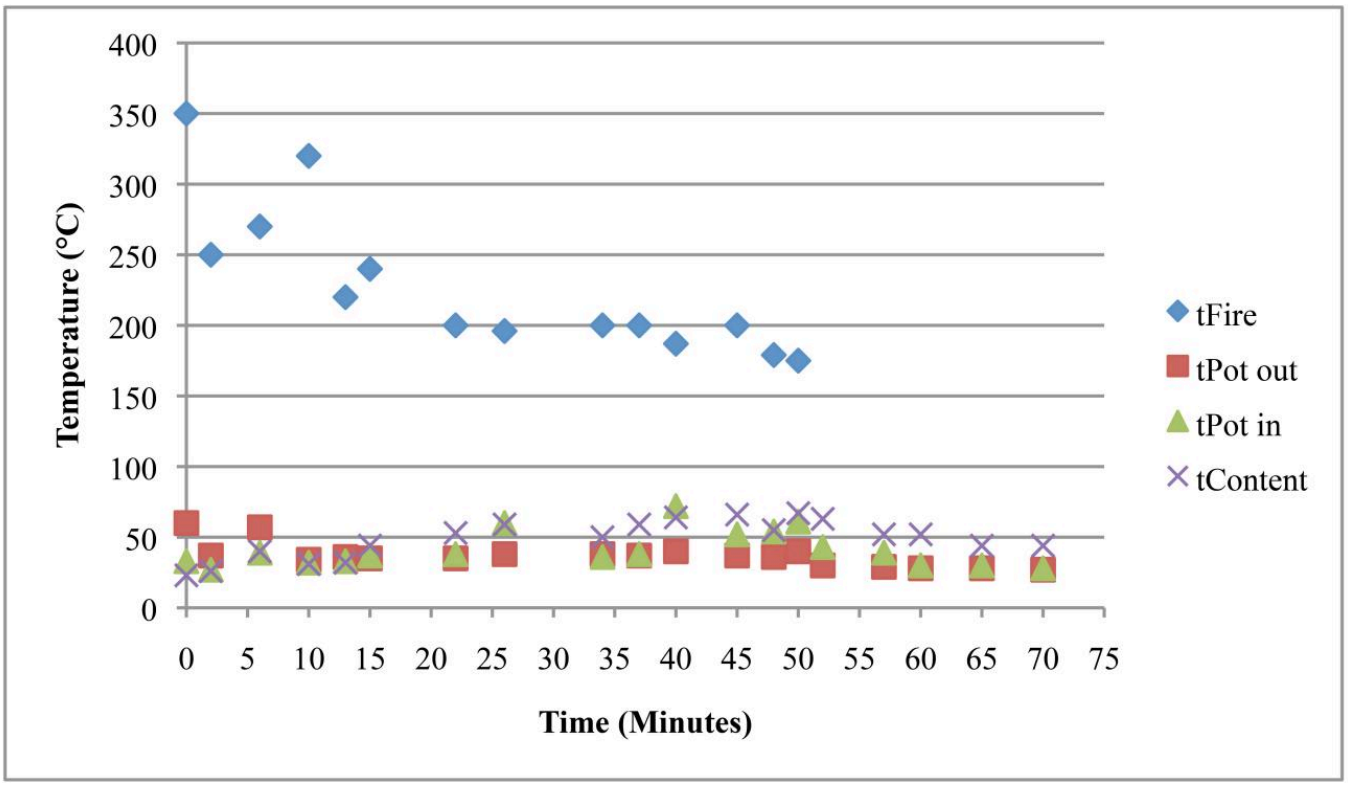

TABLE 2. EGYPTIAN COOKING POT ON WOOD FIRE.

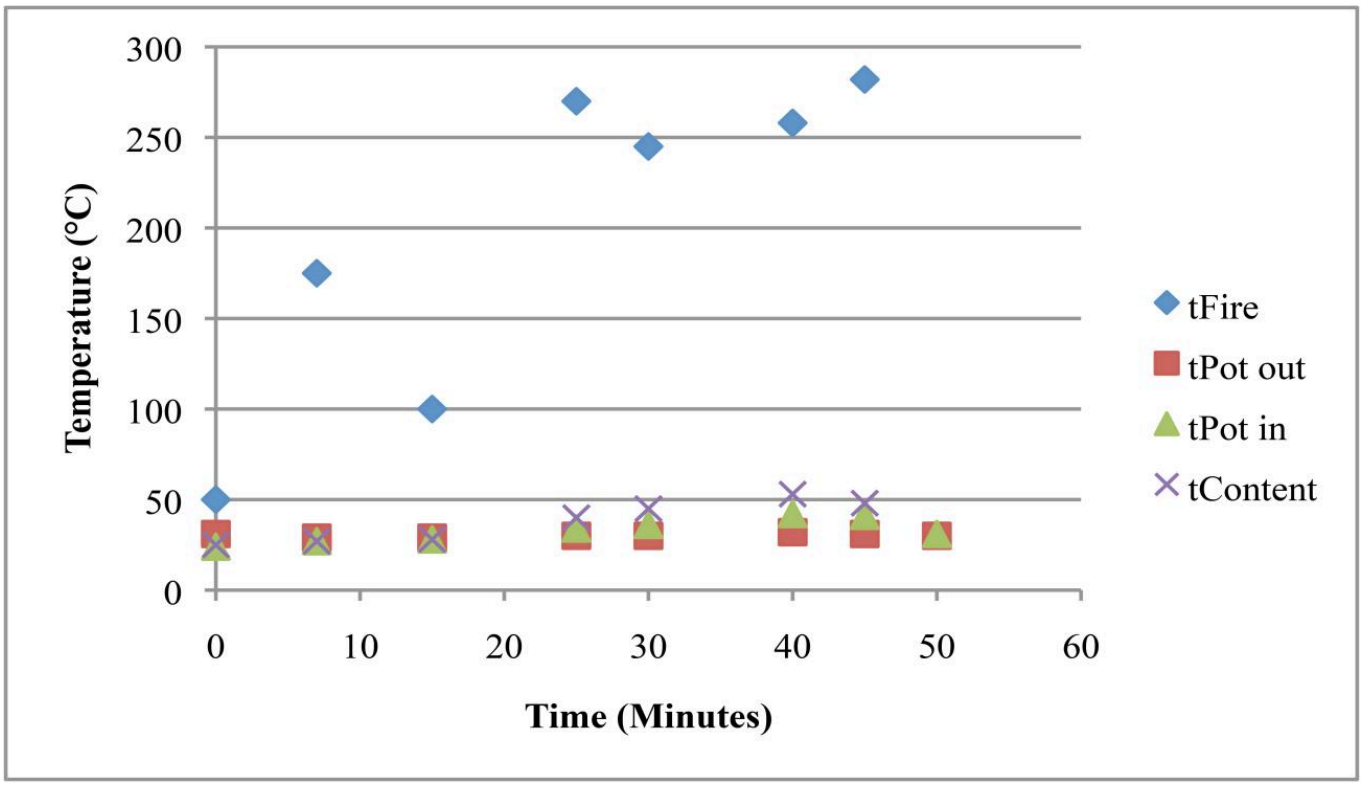

TABLE 3. EGYPTIAN COOKING POT WITH DONKEY DUNG AS FUEL (HIGH FLUCTUATIONS OF THE TEMPERATURE IN THE FIRST 20 MINUTES ORIGIN IN INACCURACIES DURING THE MEASUREMENT PROCESS).

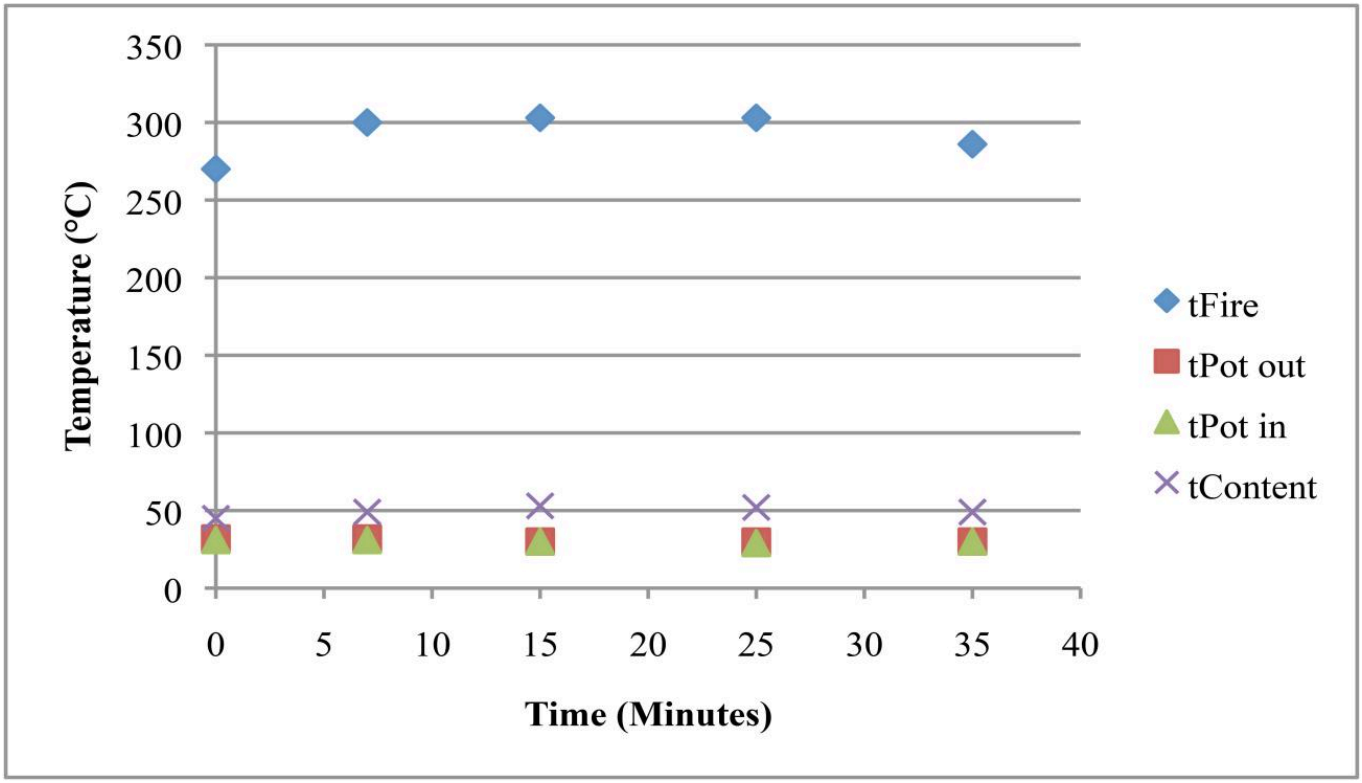

TABLE 4. EGYPTIAN COOKING POT ON FIRE DOG AND DONKEY DUNG AS FUEL (INSIDE AND OUTSIDE TEMPERATURE OF THE POT NEARLY DO NOT DIFFER).

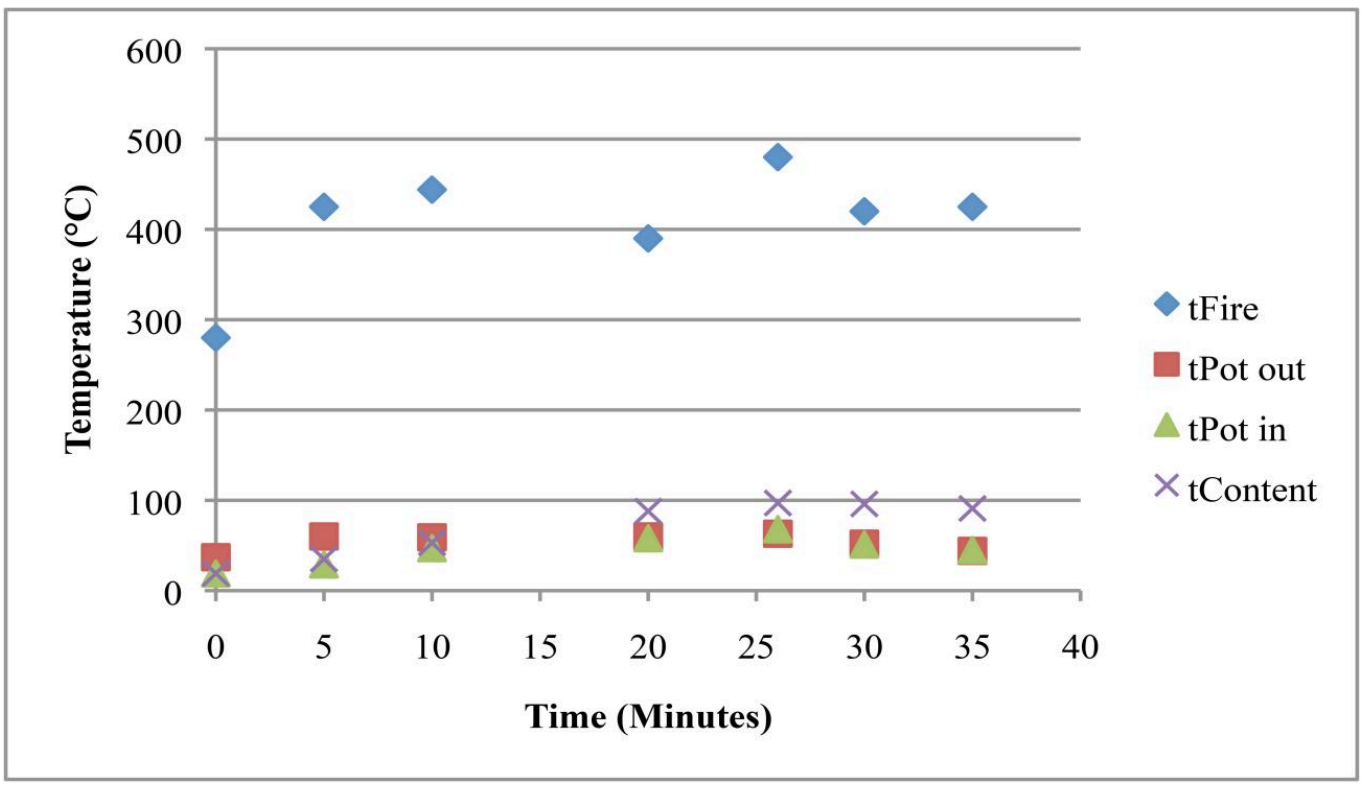

TABLE 5. EGYPTIAN COOKING POT WITH HORSE AND DONKEY DUNG AS FUEL.

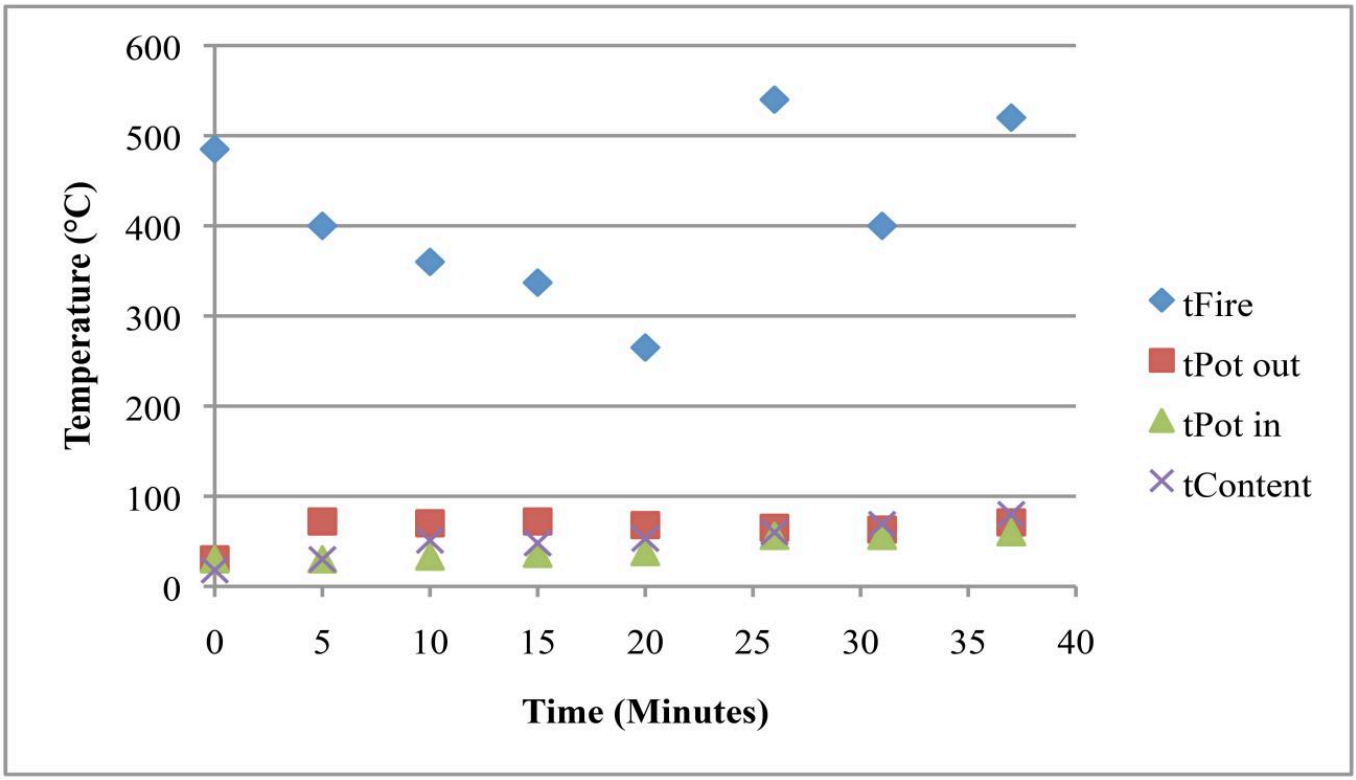

TABLE 6. EGYPTIAN COOKING POT FILLED WITH BULGUR, SUCCESSFUL BRAISING; FUEL MIX OF HORSE, DONKEY AND SHEEP DUNG.

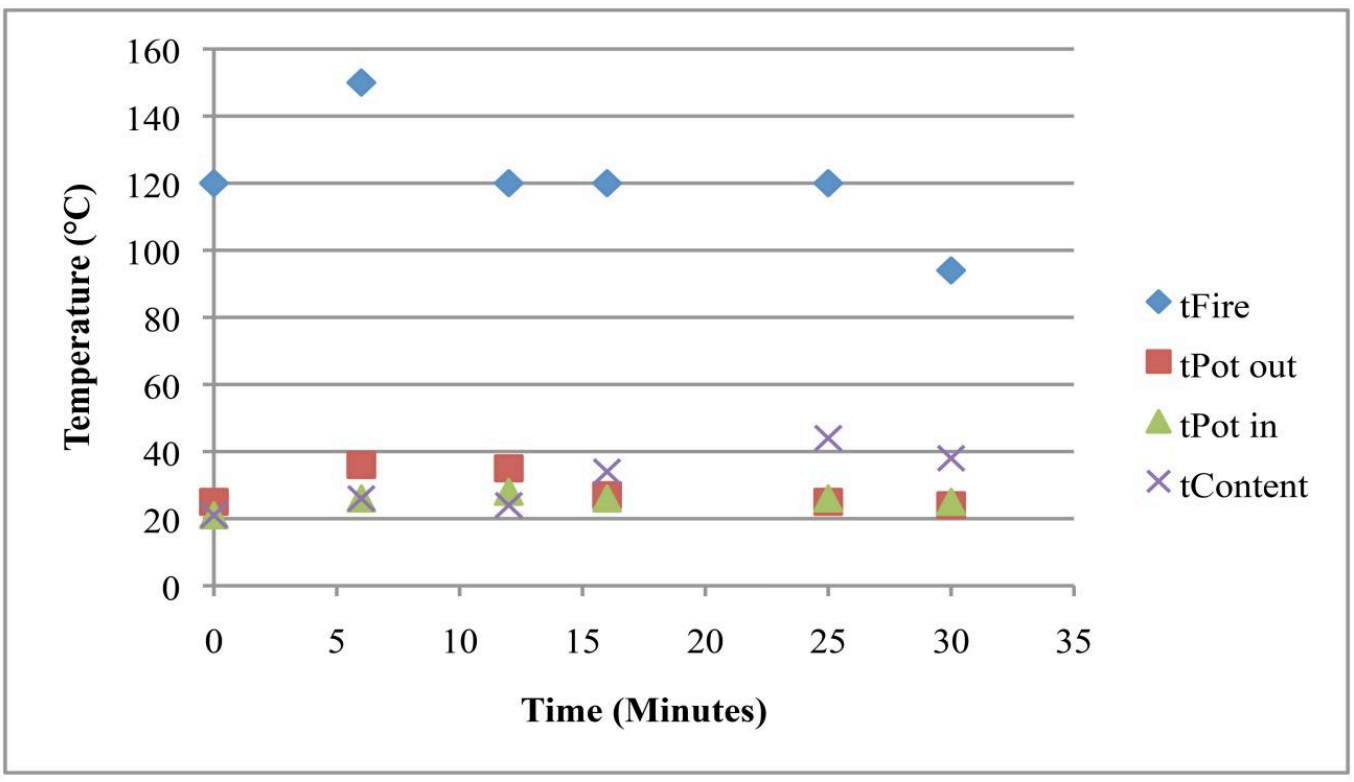

TABLE 7. NUBIAN COOKING POT WITH COW DUNG AS FUEL.

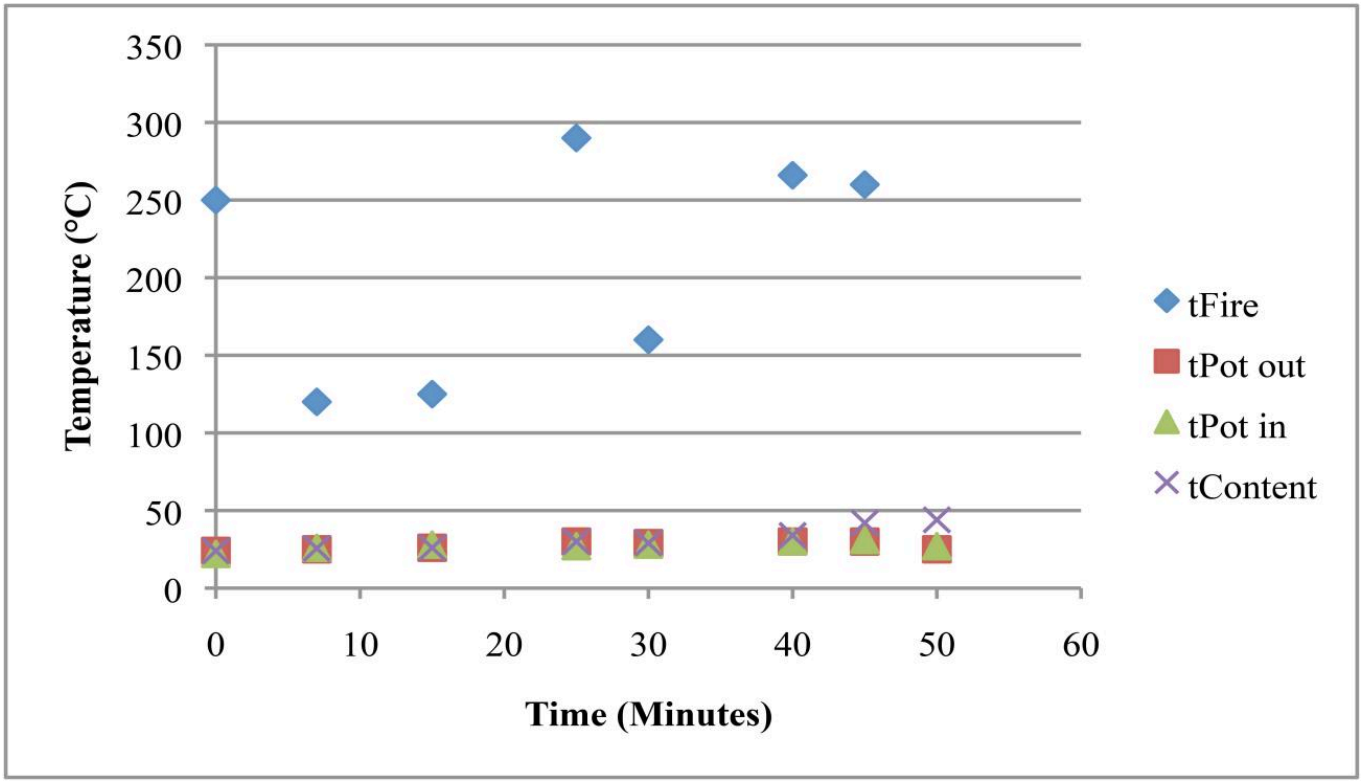

TABLE 8. NUBIAN COOKING POT WITH SHEEP AND GOAT DUNG AS FUEL.

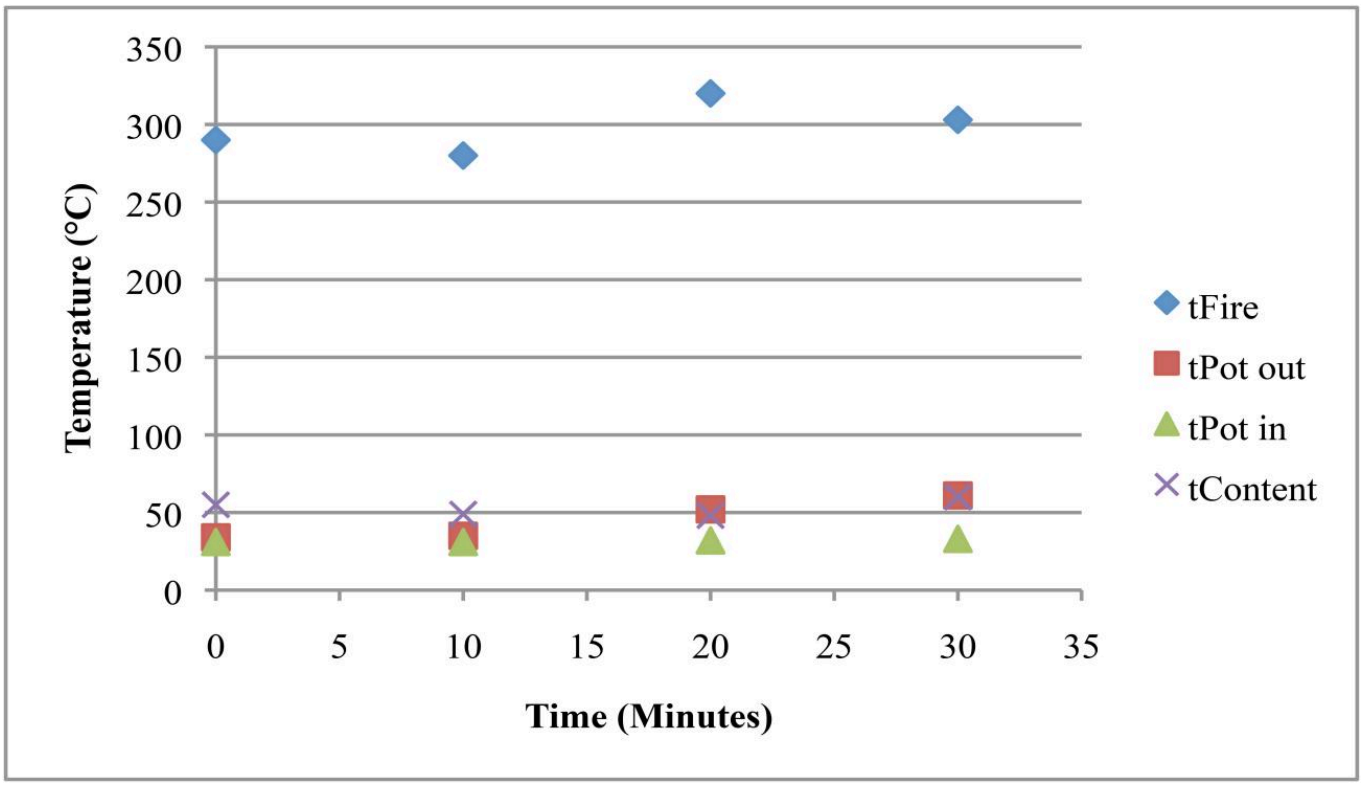

TABLE 9. NUBIAN COOKING POT ON FIRE DOG WITH A FUEL MIXTURE OF SHEEP AND GOAT DUNG.