Human skeletal remains from the Mesolithic site of Sheikh Mustafa (Central Sudan). An anthropometric and palaeodietary analysis

Los restos óseos humanos del yacimiento mesolítico de Sheikh Mustafa (Sudán Central). Estudio antropométrico y de paleodieta

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ABSTRACT

The human remains of an eight years old subadult found in the excavation of the Sheikh Mustafa site (Central Sudan) have been analysed for anthropometric description and palaeodiet determination. Comparison of the human sample with animal bone and soil samples from the same context has allowed to evaluate the diagenetic contamination effects on the human sample. The individual had a basically vegetarian diet with a milk and fish component; molluscs and meat seem to have been minor.

KEY WORDS Anthropometry, Trace elements, Ancient diet, Khartoum Mesolithic, Central Sudan

RESUMEN

Análisis antropométrico y de paleodieta de los restos humanos de un subadulto de ocho años de edad recuperados en la excavación del yacimiento mesolítico de Sheikh Mustafa (Sudán Central). Se ha comparado la muestra con otras de hueso animal y del suelo circundante para evaluar los efectos diagenéticos de contaminación. El individuo tuvo una dieta fundamentalmente vegetariana incorporando la ingesta de leche y pescado; los moluscos y la carne forman parte de la dieta en menor grado.

PALABRAS CLAVE Antropometría, Elementos traza, Paleodieta, Mesolítico de Jartum, Sudán Central

1. Anthropometric analysis

Three dental pieces and a few upper cranial remains coming from a Mesolithic single individual have been anthropologically analysed. They were found at 40 cm deep in square G19 of the Sheikh Mustafa site in Central Sudan (15º 29' 27'' N / 32º 45' 55''), dated to 7930-7600 bp (Fernández *et al.* 2003). Contrary to other recent human remains from this site and in the other excavated sites at the region, the remains studied here come from undisturbed deposits, and thus can be confidently considered as of Mesolithic age.

The remains consisted of 35 small fragments of the cranium, including part of the temporal petrosa, and three teeth, namely pieces nos. 16, 36 and 55 (Figure 1). Tooth 16 is an upper right first molar with a partially broken root; its medial face seems to fit in the distal face of the deciduous tooth 55. Tooth 36 is a lower left first molar with five cusps and interproximal contact facet in the medial face. Tooth 55 is an upper right deciduous molar with four cusps. Superficial wear in teeth 16 and 36 is of type 2 in the Holly Smith scale, affecting especially the paracone and hipocone. Wear in tooth 55 merges the two proximal cusps through the exposed dentine. There are not signs of caries or hypoplasia in any of the teeth. Height dimensions between the amelocementary line and the four bigger cusps apex are indicated for every quadrant in table 1.

The development degree of the analysed teeth, especially in their roots, as well as the wear condition of crowns and the presence of a deciduous molar, allow to estimate the age of the individual in 8 years ± 24 months, according to the Ubelaker (1989) dental scale.

2. Dietary analysis

Introduction

Techniques for the dietary analysis of past populations through the chemical analysis of human bones developed in the last 30 years. They have allowed a direct approach to the actual food eaten by past people. The new methods have come to complement more classical approaches such as faunal and vegetal analysis

S. MUSTAFA	Dental Quadrant			
Tooth	**Mesiolingual**	**Mesiobucal**	**Distolingual**	**Distobucal**
55	4.65	5.04	4.59	4.80
16	7.46	7.41	6.73	6.44
36	6.83	5.97	7.11	6.79

Table 1.- Dental crown height dimensions in the Sheikh Mustafa individual teeth.

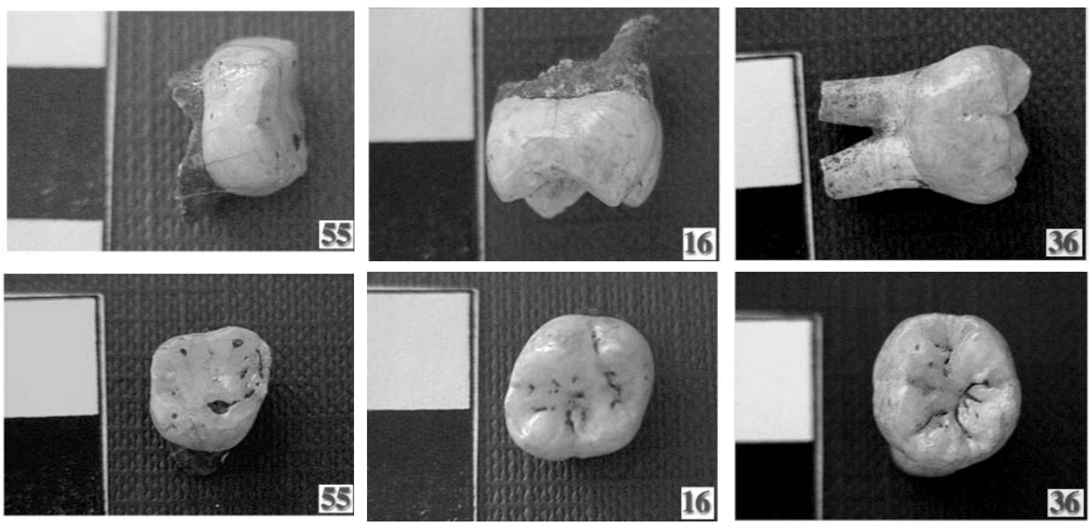

Figure 1.- Deciduous and permanent dental pieces from the individual excavated in the Sheikh Mustafa Mesolithic site.

	Food source	Trophic chain	Comments
Ba	Plant fibre, berries, tubers, vegetables, nuts, meat	Herbivore-carnivore	Diagenetic
Cu	Crustaceans, molluscs, viscera, meat, nuts, honey	Carnivore-herbivore	Similar to Barium
Mg	Green plants, cereals, vegetables, nuts, meat	Herbivore-Carnivore	High levels are related to cereals-rich diets
Sr	General marine and plant foods	Herbivore-Carnivore	Useful in palaeodiet analysis
V	Tubers, vegetables, nuts, milk	Herbivore-Carnivore	Of little use yet in palaeodiet analysis
Zn	Crustaceans, molluscs, meat, cereals	Carnivore-Herbivore	Diagenetically stable. Very used in palaeodiet analysis

Table 2.- Food source and trophic chain expected for six chemical elements.

at the sites, investigation of archaeological remains (silos, pottery and other tools, rubbish pits, etc.), or physical health indicators (caries, tooth wear, anaemic processes, etc.). Some important techniques include trace-elements analysis, stable isotopes analysis (δC^{13}, δN^{15}) or microscopic analysis of striations and phytoliths on the teeth (Price and Kavanagh 1982; Price *et al*. 1985; Schoeniger 1989; White 1993; White and Schwarcz 1994; Malgosa and Subirá 1996).

Trace-elements as palaeodiet indicators begun to be applied when Toots and Voorhies (1965) determined ancient food chains on the basis of Strontium content in fossil bones. Many other chemical markers have been since incorporated to the analytical techniques, namely Ba, Cu, Mg, Sr, V or Zn (Hatch *et al*. 1985; Oster 1988; Zumkley and Spieker 1988; Runia 1988; Francalacci 1989; Katzenberg 1992; Sandford 1992). Table 2 shows some of these chemical elements and their trophic level in the food chain. One of the most useful elements is the Barium which is strongly related to vegetal foods and whose heavier atomic weight over Calcium makes its digestive absorption slower, thus making differences among trophic levels easier to distinguish (Ezzo *et al*. 1995). Also Magnesium and Strontium have been associated with vegetal diet, yet the latter has been revealed recently as also related to marine and river foods. Vanadium content points to milk and some plants consumption, and Copper and Zinc are usually related to a carnivore diet (see table 2).

The methods

Dietary analysis has been carried out with a sample of cranium bone from the aforementioned human individual, less than one gram in weight. For comparison, a sample of slightly burnt cortical bone from a big herbivore, coming from the same archaeological deposit than the human, was also analysed. Also a sample of earth from the same context has been examined.

The bone samples were mechanically treated eliminating a superficial layer 2 mm thick with a carbide drill to avoid external contaminants. Later on they were weighted and desiccated at 105º C up to constant weight during 24 hours. Then they were oven-burn from 100º to 600º C during 10 hours. All possible organic residues were in this way eliminated. A solution in HNO_3 was then made on a microwave oven and later filtered to exclude any silica residues. Finally a further solution was made in tri-distilled de-ionized water. The same treatment was applied to the soil sample, with the exception of initial drilling.

S. Mustafa	Ca	P	Mg	Fe	Zn	Sr	Cu	V
Lines	317.923	213.618	279.553	238.204	213.856	407.771	324.754	292.402
NIST400 Experim.	38.02 %	17.89 %	6732	652	183	241	2.5	-
NIST400	38.18 %	17.91 %	6840	660	181	249	2.3	-
SO-2 Experim.	1.89 %	0.29 %	5123	54300	120	298	6.2	58
SO-2	1.96 %	0.30 %	5400	55600	124	340	7	64

Table 3.- Wavelengths of analytical lines and international standard values (Values in ppm except for Ca and P in percentages).

Analytic checks were made according to the standard protocol that has been established in our own research group at the CAI Spectrometry Service of the Universidad Complutense of Madrid (Martín 1993; González-Abad 2000). The JY-70 Plus model was used. Concentrations of Zn, Fe, Cu, Sr, Ba, V and Mg are expressed in micrograms/gram (ppm, parts per million) of ash, and those of Ca and P in percentages. Each analysis was independently repeated three times, mean values being presented here. Duplicated international standards were used for the bone (NIST 400) and soil (SO-2). Wavelengths of analytical lines and international standard values for each element are shown in table 3.

Diagenetic problems

An effect of cultural or tafonomic processes, diagenetic contamination is the greatest problem for bone analysis because it can disrupt the biological integrity of samples, modifying to an unknown extent their chemical composition. Usually these changes consist in homogenising the bone content with the surrounding soil composition (Price and Kavanagh 1982; Kyle 1986; Price 1989b; Sillen 1989). Sometimes grave furnishings themselves can add to other contamination factors (Trancho *et al.* 1995, 1998).

Some investigations have shown that contamination mainly affects the bone surface, and thus the first 400 µ must not be analysed (Lambert *et al.* 1985, 1989). Particular elements, such as Fe, Mn, Al and Cu, are more apt to have their concentration altered, while Sr, Mg, and Zn are basically stable (Pate and Brown 1985; Lambert *et al.* 1985; Buikstra *et al.* 1989). Besides drilling, chemical cleaning has also been used to extract the superficial parts, with diluted acetic acid (Krueger and Sullivan 1984) or hydroxilamine hydrochlorate (Price *et al.* 1992). Yet the treating has serious shortcomings as less material is left for analysis after several cleanings, this affecting differently to particular elements (Lambert *et al.* 1989). Furthermore, sometimes the treatment cannot eliminate the bone carbonates (Baraybar and De la Rua 1995).

Diagenetic effects also vary according to the bone type. Sillen and Kavanagh (1982) and Beck (1985) have shown that trabecular bones behave differently than more compact bone parts. In a previous research (Trancho *et al.* 1995; Jimeno *et al.* 1996) we have published that significant differences were observed on both bone tissue types depending on the elements concerned. Fe and Ba maintain their concentrations in trabecular tissue, while Ca and P would lose them in a greater degree. After these results, use of compact tissue is always advisable for palaeodietary analysis, as it has been made in the present research.

Results and discussion

An evaluation of contamination processes in our sample was made by comparing trace elements in the bone and in the soil sample (Table 4). A check was also made of the preservation of hydroxyapatite in the bone by means of the Ca/P index (see later). As it can be seen comparing values in table 4 and those from table 6, trace elements are generally more abundant in the soil than in the bone sample. The same fact has been noticed in other contexts for the case of Fe and Cu (Ezzo 1994a). Barium is a somewhat diagenetic element, and probably this is the origin of its concentrations at both samples being more similar. Also Magnesium has been observed to have diagenetic behaviour (Buikstra *et al.* 1989), but it does not seem to be the case here.

Ca/P index was calculated to assess the preservation of apatite matrix in the bone (Table 5). Theoretical value for the index is of 2.16, and values over 2.5 are considered indicative of diagenesis (Buikstra *et al.* 1989). In our case, estimates are bigger than 2.5, suggesting that alteration of hydroxyapatite has occurred. Looking at values of each particular element, however, shows that Ca has been adequately preserved in the human bone sample - but not so in the animal bone, probably by the heating effect, cf.

Soil sample	T-1	SO-2 Experimental
Ca	54350 ± 206	18900 ± 427
P	20500 ± 75	2979 ± 48
Mg	4174 ± 9	5123 ± 114
Fe	26540 ± 70	54300 ± 1627
Zn	71.7 ± 0.5	120 ± 1
V	< 8	58 ± 3
Cu	24 ± 0.2	6.23 ± 0.12
Sr	176.9 ± 0.7	298 ± 2
Ba	302.7 ± 7.6	1005 ± 15

Table 4.- Analytical results from the soil sample and the international standard SO-2 for soils.

Sample	Index Ca/P
Human	2.74
Faunal	2.85

Table 5.- Calcium/Phosphorus (Ca/P) indexes for the analysed organic samples.

Trancho *et al*. 1995. Yet the loss of P in both samples has been big enough to admit the reality of diagenetic processes. The soil analytical results reveal that Ca and P have unusually high values (Table 4), this being another suggestion of the possibility of soil contamination over the bones.

Table 6 shows the trace elements contents of both bone samples, human and animal. The overall impression is that the human sample has more Zn, V and Sr than the faunal bone, the latter having more Cu than the first one. Zinc content may be a reliable indicator of meat protein consumption (Ezzo 1992; González-Abad 2000), yet the physiological model explaining its trophic performance is not yet fully understood (Ezzo 1994b; Trancho *et al*. 1997; Robledo 2003). The lower quantity of Copper –another meat indicator– in the human bone, though, appears contradictory to the Zn content. An explanation could be contamination in the animal sample, since values in the surrounding soil are quite higher than in both bone samples. Lower Cu content in the human bone may also be attributed to a low ingest of molluscs, which agrees with the total absence of shell remains at the site of Sheikh Mustafa (Chaix 2003). As regards the higher quantity of Vanadium in the human sample, it could indicate significant milk, tubers and vegetables consumption by the child individual (Trancho *et al*. 1996; Robledo 2003).

Sheikh Mustafa	Human (mean + ds)	Faunal (mean ± ds)
CA	36.76 ± 0.01	37.84 ± 0.3
P	13.43 ± 0.1	13.27 ± 0.1
MG	1226± 22	1286 ± 7
ZN	117.7 ± 0.5	84.05 ± 1.1
FE	422.1 ± 3.3	379.9 ± 1.1
V	36.14 ± 0.8	29.9 ± 0.1
CU	6.89 ± 0.1	25.24 ± 0.1
SR	809.3 ± 2.4	547.2 ± 5.2
BA	210.0 ± 1.1	226.1 ± 1.4

Table 6.- Trace element contents in the human and animal samples from Sheikh Mustafa. All values in ppm except Ca and P in percentages.

Strontium and Barium in bones have been related to the consumption of plant-foods and/or fish and other marine resources (Burton and Price 1990). The slightly higher value of Ba in the herbivore bone is thus expectable. The difference could also be attributed to the different plants consumed, fibre-rich by the herbivore and tubers and berries in the case of the child.

The Strontium is not metabolically controlled, what results in a big correlation between ingested and bone preserved quantities, and thus it is a very useful indicator of past diets (Ezzo 1994a). The greater abundance of Sr in the human than in the animal bone is an unexpected result, since the animal is a strict herbivore and the contrary would have been anticipated. Wild plants were very probably eaten by the site dwellers, as seed impressions of *Sorghum* and *Setaria* have been recorded in pottery sherds excavated from the site (Magid 2003). On the other hand, the slightly smaller contents of Ba and Mg in the human sample suggest a lesser importance of vegetal foods. One plausible explanation is that the Strontium high content was not produced by food-plants but because of a fish and molluscs predominant diet. To verify the hypothesis the index log(Ba/Sr), which has been proposed as a good indicator for fish consumption (Burton and Price 1990), was calculated. The obtained value, -1.35, is close to the mean number recorded among American fishing populations, which is –1.6 (Ibid.). A predominant fish component seems more probable than one including also a mollusc diet (as in other Sudanese Mesolithic sites, cf. Palmieri 1983), since Cu values are lower than expected. The result is again in accordance with faunal data from the site, where large quantities of fish were found (Chaix 2003: table 3).

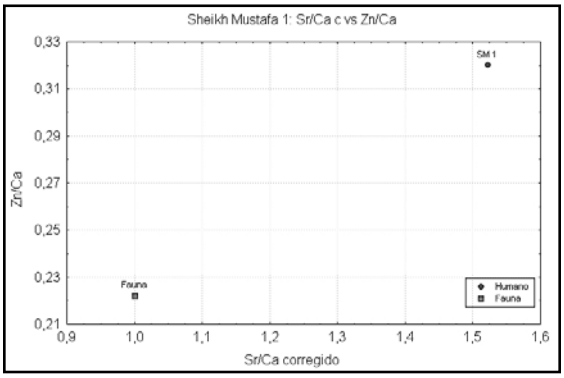

Figure 2.- Plot diagram of Zn/Ca and corrected Sr/Ca indexes for the human and animal samples.

To reduce the biasing effect of Strontium content in the soil, a correction may be made of the index Sr/Ca with respect to the previous trophic level, that is, a strict herbivore level (Fornaciari and Mallegni 1987). In figure 2, which shows the plot of this index with respect to the Zn/Ca index, the values for the human sample are far apart from the animal ones, their bigger numbers suggesting the predominance of fish component. As the index Zn/Ca is lower than 0.35, this is another indication of the unimportance of meat in the diet (Ibid.).

To sum up, the diet of the child buried in the Mesolithic site of Sheikh Mustafa consisted of food-plants with a small milk component and a strong fish factor. Crustaceans and molluscs, as well as meat seem to have been absent or unimportant in the diet. The faunal assemblage recorded at the site, with quite a lot of fish in the lower levels and lacking molluscs (Chaix 2003), is in accordance with the palaeodietary results.

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