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TECHNICAL NOTE

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A Preliminary Investigation of the Stages of Adipocere Formation*

ABSTRACT: Adipocere is a postmortem decomposition product which forms from a body's adipose tissue. This study aimed to chemically demonstrate the process of conversion from adipose tissue to adipocere. Samples of adipocere were collected from pig cadavers that were allowed to decompose for varying intervals. Samples of soil were collected from beneath the cadavers and analyzed to determine the leaching effect of adipocere. Gas chromatography/mass spectrometry (GC/MS) was used to quantify the fatty acid composition of pig adipocere. Fourier transform infrared spectroscopy (FTIR) was used as a confirmatory test and to identify other components such as triglycerides and calcium salts of fatty acids. The study demonstrates the process of adipocere formation and the stages of formation through which the process passes using chemical techniques.

KEYWORDS: forensic science, forensic anthropology, adipocere, gas chromatography/mass spectrometry (GC/MS), Fourier transform infrared spectroscopy (FTIR), fatty acids

Adipocere is a grayish-white postmortem decomposition product that can vary in consistency from crumbly to paste-like. In the early stages of formation it produces a strong distinctive odor which can be recognized by cadaver dogs trained to detect human remains. Adipocere formation referes to the postmortem conversion of adipose tissue into a solid material comprising fatty acids. Decomposition of adipose tissue starts almost immediately upon death. At the onset of decomposition, triglycerides are hydrolyzed by bacterial enzymes that serve to cleave the fatty acids from the glycerol molecule (1). The hydrolytic process causes a mixture of free fatty acids to form, including unsaturated and saturated fatty acids. As decomposition proceeds, the quantity of free fatty acids increases while the amount of triglycerides decreases. Provided there are sufficient amounts of enzymes and water, the hydrolytic breakdown will occur until no triglycerides remain (2). In addition, hydrogenation of the unsaturated fatty acids, namely palmitoleic [$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$], oleic [$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$] and linoleic [$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$] acid, occurs to yield saturated fatty acids including myristic [$CH_3(CH_2)_{12}COOH$], palmitic [$CH_3(CH_2)_{14}COOH$], and stearic [$CH_3(CH_2)_{16}COOH$] acid. At this stage, conversion is said to be complete and providing no other chemical changes occur, the saturated fatty acids remain as adipocere (3). Figure 1 details the degradation of adipose tissue from the commencement of decomposition through to adipocere formation. At some time after its formation, adipocere may decompose under the influence of bacterial or chemical degradation.

During hydrolysis and hydrogenation a number of by-products may form. The cleaved fatty acids may attach to sodium or potassium ions present in the interstitial fluid and cell water, respectively (4). When a body is placed in water or soil for burial, these ions can be displaced by calcium ions to form calcium salts of fatty acids. The utilization of sodium and potassium ions most likely occurs early in the decomposition process and in later stages of decomposition these ions are replaced by calcium ions. Depending on the presence of various microorganisms, hydroxy fatty acids may also form during the decomposition process. A number of studies (5–7) have reported the identification of hydroxy fatty acids in adipocere with the most common form being 10-hydroxy stearic acid.

In a forensic context, adipocere is important because of its ability to slow decomposition and, in some cases, preserve the remains. Ethical restrictions in Australia prevent the use of human bodies in decomposition trials and current debate suggests that decomposing pigs are the next most reliable model (8,9). The decomposition of pig cadavers during the spring/summer months of Western Australia allowed for the successful formation of adipocere and samples to be collected for this study.

Pig adipocere was originally analyzed as early as 1847 by Gregory (5), who concluded that it is composed of palmitic acid, stearic acid, and lime. Some years later, Ruttan and Marshall (5) conducted an analysis into a slab of pig adipocere that had been buried for approximately 45 years and identified the major components of pig adipocere as palmitic, stearic, oleic, and hydroxy-stearic acids, with small amounts of calcium soaps also present.

More recently, pig cadavers have been used to form adipocere under controlled laboratory conditions in a study conducted by Yan et al. (10). The degradation of subcutaneous fat in distilled water, chlorinated water, and saline water was investigated. The study presented a preliminary model for investigating postmortem adipocere formation using liquid chromatography and identified a quantitative analytical method for determining postmortem interval. A study by Mellen et al. (11) also formed adipocere under controlled

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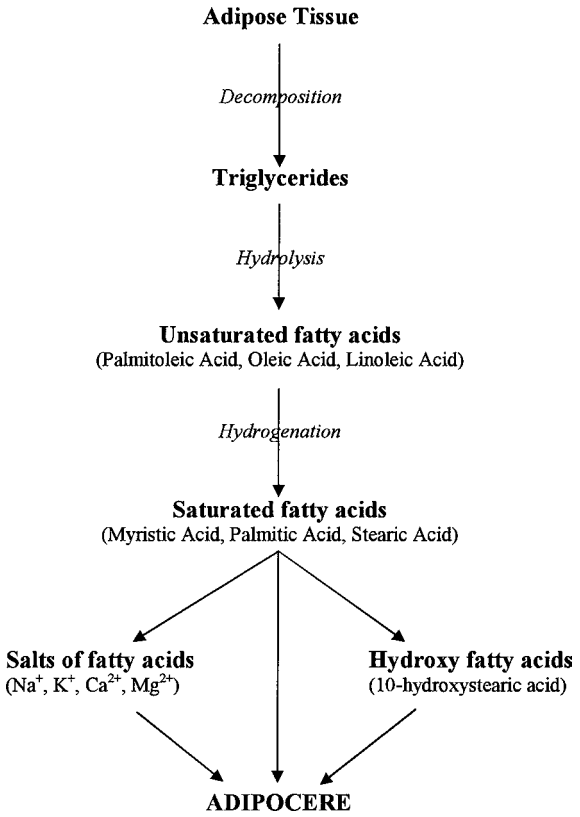

FIG. 1—*Process of adipocere formation.*

conditions utilizing human adipose tissue submerged in water. The study investigated the effects of temperature and clothing on adipocere formation.

Several studies involving adipocere formation in water have been cited (10,11) and investigations of adipocere formation in glaciers (12–15) were also extensive following the discovery of The Tyrolean Iceman in 1991. However, with the exception of the pioneering study conducted by Mant (16) in 1963, minimal published data are available on the formation of adipocere in soils. Although Mant observed adipocere formation in grave soils and noted factors which may have affected its formation, his laboratory experiments involved the formation of adipocere in water.

Previous studies by the authors (17,18) suggested that the occurrence of adipocere formation in grave soils was not uncommon and, consequently, further investigations into its formation were desirable. The present paper investigates adipocere formation in soils utilizing pig cadavers to mimic human decomposition. The study demonstrates, by chemical composition, the formation of adipocere in soils from adipose tissue and the various stages that the process passes through.

Materials and Method

Sample Collection

Decomposition trials being conducted in Western Australia allowed the authors to obtain ten soil and adipocere samples for this study. The decomposition trials were conducted using 45 kg pigs that had been reared at a pig farm on identical diets. These animals were chosen as they are considered to best mimic human decomposition (9). Each pig was buried in a shallow grave and the duration varied to investigate a range of decomposition intervals. The trials were conducted in the Harry Waring Marsupial Reserve situated 19 km south of Perth, Western Australia. The site environment was composed of woodland vegetation type on a sandy soil, with average yearly rainfall of 900 mm.

The samples collected from the decomposition trials included soil sampled from the region directly beneath the decomposing remains, and adipocere sampled directly from the cadaver. Samples of adipocere were collected from the abdominal/lower trunk region. In each instance, the burial duration was known.

A sample of pig adipose tissue was collected from the abdominal/lower trunk region to determine its fatty acid composition prior to decomposition and adipocere formation.

Sample Preparation for GC/MS

Total Fatty Acid Analysis—Two mg of adipose tissue sample was accurately weighed into a sterlized reacti-vial. One mL of chlorform was added and the sample sonicated for 15 min. The chloroform layer was drawn off and evaporated under a flow of nitrogen. One mL of 0.1M NaOH was added and the vial heated at 70°C for 5 min. After cooling, 2 mL of 0.2M HCl and 1 mL of hexane were added and the mixture was extracted for 10 min. The upper hexane layer was drawn off and 0.25 mL of hexamethyldisilazane (HMDS) added. The vial was again heated at 70°C for 5 min and an aliquot removed for analysis by GC/MS.

Free Fatty Acid Analysis—Two hundred mg of soil sample or 2 mg of adipocere sample were accurately weighed into a sterilized reati-vial. One mL of chloroform was added and the mixture sonicated for 15 min. The chloroform layer was drawn off and placed in a sterilized screw top tube. 0.25 mL of hexamethyldisilazane (HMDS) was added to form the trimethylsilyl esters of fatty acids and the tube heated at 70°C for 15 min. Upon cooling, an aliquot was removed and placed in a vial for analysis by GC/MS.

Chromatographic Analysis

Chromatographic analysis was performed on a Hewlett Packard 5890 Series II Gas Chromatograph coupled with a Hewlett Packard 5970B Series Mass Selective Detector.

A 1 μL aliquot of the sample was analyzed on a DB5-MS (J&W Scientific, USA) fused-silica capillary column (30 m × 0.25 mm × 0.25 × μm, 5% phenylmethyl polysiloxane). The carrier gas was helium at a column pressure of 100 kPa. The initial column temperature was 100°C and the initial time was 1 min. The temperature was increased at 7°C min^{-1} to 275°C where it was held for 5 min. All injections were in the splitless mode using a HP 7673 autosampler and injector. The analysis was conducted in selected ion monitoring (SIM) mode, and identified only those fatty acids known to comprise adipocere. The saturated fatty acids considered were myristic, palmitic, stearic, and 10-hydroxy stearic acid. The unsaturated fatty acids considered were palmitoleic, oleic, and linoleic acid.

Solutions of trimethylsilyl esters of the fatty acids were prepared from commercially available standards and analyzed by GC/MS. A plot of their concentrations versus peak areas was determined to be linear and established the accuracy of the method. Peaks relating to the trimethylsilyl esters of the fatty acids were identified by comparison of their retention time (RT) and mass spectra against the NIST98 Mass Spectral Library. The concentration of each fatty acid was determined by measuring the peak area and calculating the relative concentration as compared to the other fatty acids detected. Each sample analysis was repeated three times and an average concentration determined.

TABLE 1—*Relative fatty acid (%) composition of adipose tissue and adipocere samples.*

Sample Name	Age (months)	Sample Type	Myristic Acid	Palmitic Acid	Palmitoleic Acid	Stearic Acid	Oleic Acid	Linoleic Acid	Hydroxy Stearic Acid
				EARLY STAGE					
Adipose	...	...	1.5	33.0	0.5	27.0	36.0	2.0	0.0
A	13	Soil	1.4	39.4	0.5	21.4	36.0	1.3	0.0
B	13	Soil	1.4	47.5	0.4	26.1	24.6	0.0	0.0
				INTERMEDIATE STAGE					
C	5	Adipocere	2.9	46.6	0.2	37.9	12.4	0.0	0.0
D	14	Soil	0.2	43.8	0.0	55.2	0.8	0.0	0.0
E	14	Soil	0.3	45.5	0.0	48.1	5.8	0.0	0.3
				ADVANCED STAGE					
F	8	Adipocere	2.6	54.7	0.0	27.0	15.7	0.0	0.0
G	8	Adipocere	4.9	55.9	0.0	32.0	7.2	0.0	0.0
H	13	Adipocere	0.9	58.4	0.0	37.0	3.4	0.0	0.3
I	6	Adipocere	0.9	60.8	0.0	33.8	4.5	0.0	0.0
J	8	Adipocere	1.7	60.8	0.0	31.9	5.5	0.0	0.0

Sample Preparation for FTIR

Ten mg of adipocere was accurately weighed and ground together with 10 mg of powdered KBr using a mortar and pestle. The mixture was placed in an aluminum oxide microsampling cup for analysis. Background spectra were recorded using 20 mg of powdered KBr.

Spectroscopic Analysis

The microsampling cup containing the mixture was placed into a Nicolet diffuse reflectance infrared sampling accessory. The infrared spectra were recorded using a Nicolet Magna-IR 760 Fourier transform infrared spectrometer equipped with a deuterated triglycine sulfate detector. Sixty-four scans over the frequency range 4000–500 cm^{-1} were recorded and Fourier transformed to give a resolution of 4 cm^{-1}.

Results

Total Fatty Acid Analysis

A sample of pig adipose tissue was analyzed to determine the fatty acids which were present in triglycerides and, therefore, likely to be identified within soil and adipocere samples. The composition of the major fatty acids in triglycerides of pig adipose tissue was determined using GC/MS. The major fatty acids and their percentages are outlined in Table 1. The fatty acid composition was comparable to that in a study conducted by Kagawa et al. (19) into adipose tissue of various species, including pig.

Free Fatty Acid Analysis

The adipocere samples collected from the pig cadavers were analyzed using GC/MS to determine their fatty acid compositions. Soil samples collected from beneath the cadavers were also analyzed to determine the ability of adipocere to leach into the soils. Table 1 lists the fatty acids identified and their ratios in both the soil and adipocere samples. The samples were grouped into categories based on their similarity in overall composition to other samples. Three main categories were identified and demonstrate the various stages of adipocere formation.

The first stage in this study has been classed as early-stage adipocere formation. This stage consists of adipocere samples that have undergone only a slight degradation and have a chemical composition high in unsaturated fatty acids. Their compositions appeared similar to the composition of adipose tissue.

Sample A was a soil sample collected from beneath a pig cadaver that had been decomposing for approximately 13 months. The adipocere extracted from the soil had a composition similar to that of the pig adipose tissue which was analyzed prior to decomposition. All of the major unsaturated and saturated fatty acids were present with only slight variations between the palmitic and stearic acid concentrations of both samples. Although decomposition of the adipose tissue had occurred, the formation of adipocere was minimal and determined to be in an early stage. It seems possible that the free fatty acids were released during decomposition and thus able to leach into the soil, most likely following liquefaction of the remains. However, even with an extended decomposition interval, the soil environment did not appear to have enhanced adipocere formation.

Similarly with Sample B, a soil sample was collected from beneath a pig cadaver and adipocere was extracted. A higher concentration of palmitic acid and a lower concentration of oleic acid was evident in this sample, even though the decomposition interval was the same as Sample A. The difference in composition is likely due to factors present in the surrounding environment, which enhanced adipocere formation to a greater extent. The concentration of oleic acid is relatively high when compared with the remaining samples, placing this adipocere sample in the category classed as early-stage formation. However, the distinction between the stages of formation is unrestricted and this sample could possibly be classed as being in an early to intermediate stage of formation based on its higher palmitic acid concentration.

Figure 2 is a plot of the relative fatty acid concentration of the three samples and displays their similarities. In adipose tissue the concentration of palmitic and oleic acid is similar, with lower concentrations of stearic acid. Following degradation, as in Sample A, the concentration of palmitic acid starts to increase as hydrogenation of the unsaturated fatty acids occur (see Fig. 1). Further degradation, as evidenced in Sample B, causes the concentrations of oleic acid to markedly decrease while the concentration of stearic and palmitic acids increases. Comparison of the three graphs demonstrates the initial degradation of adipose tissue and the early-stage formation of adipocere. This stage of formation is highlighted by a decrease in unsaturated fatty acids (particularly oleic acid) and an increase in saturated fatty acids (particularly palmitic acid).

The next stage of adipocere formation in this study was classed as an intermediate stage. This stage was characterized by increased stearic acid concentrations and reduced oleic acid concentrations.

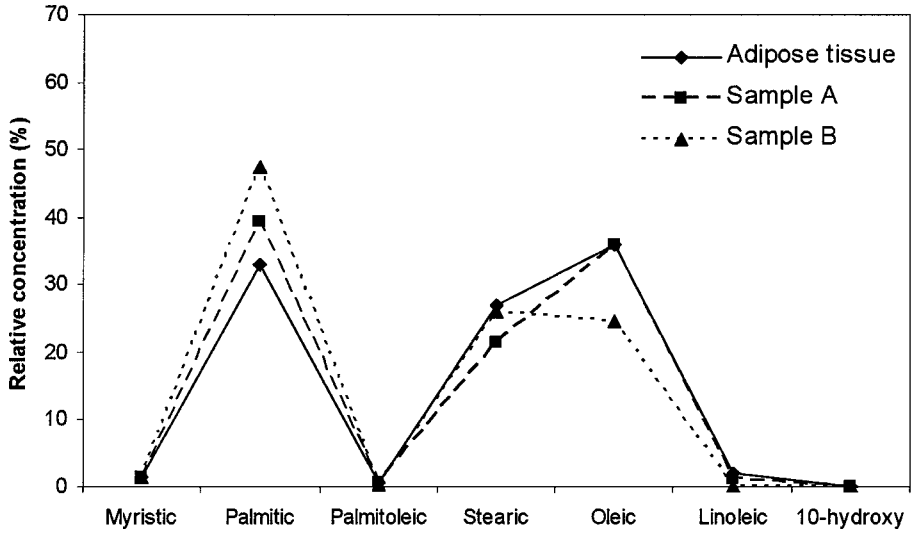

FIG. 2—*Comparison of fatty acid composition in early stage adipocere formation.*

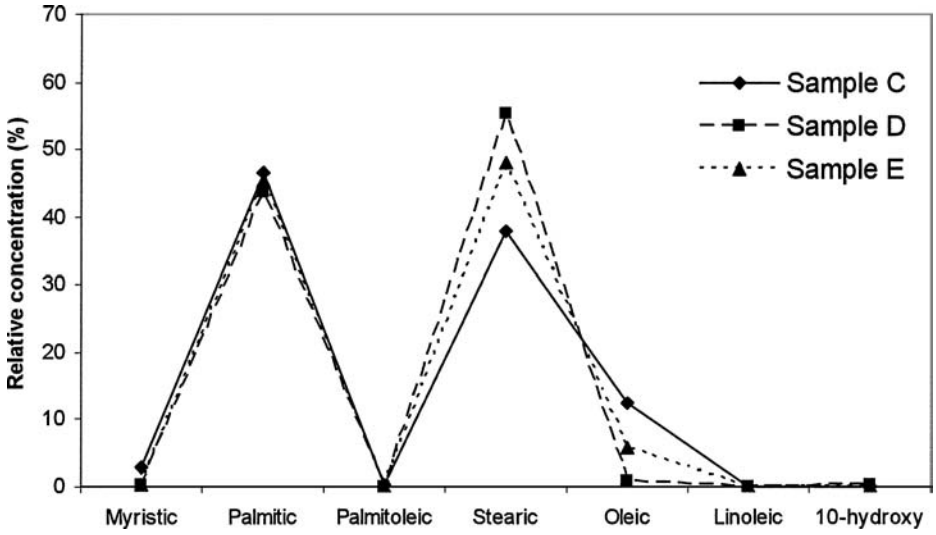

FIG. 3—*Comparison of fatty acid composition in intermediate stage adipocere formation.*

As decomposition progressed, the hydrogenation of oleic acid yielded higher concentrations of stearic acid. These concentrations were noticeably higher than the original stearic acid concentration in adipose tissue. Furthermore, palmitoleic and linoleic acid had almost completely degraded by this stage.

Sample C was an adipocere sample collected from the cadaver of a pig that had been allowed to decompose for approximately five months. A noticeable decrease in the concentration of oleic acid was evident when compared with the adipocere samples in an early stage of formation. Increases in the concentration of saturated fatty acids, and in particular stearic acid, were also apparent. Numerous studies (1,3,16) have discussed the time frame required for adipocere formation to occur and it is generally believed to take weeks or months before its formation is visible. The decomposition interval for Sample C appeared to be sufficient time for adipocere to form, yet its formation was far from being advanced and the product did not appear to be chemically stable as further hydrogenation could occur. It is likely that factors present within the decomposition environment may have retarded its formation, resulting in a less advanced stage of formation. However, these factors would need to be identified before this assumption could be confirmed.

Sample D was a soil sample collected from beneath a pig cadaver that had decomposed for approximately 14 months. Adipocere was successfully extracted from the soil and its chemical composition shown to be in an intermediate stage. Extensive hydrogenation of oleic acid had occurred as evidenced by the disproportionately high concentration of stearic acid present in the sample. Adipocere was able to leach into the soil during decomposition; however, one or more factors present in the soil environment appear to have retarded its formation, causing the sample to be in an intermediate stage of formation after burial of 14 months.

Sample E was also a soil sample collected from beneath a pig cadaver that had been decomposing for approximately 14 months. The adipocere extracted from the soil yielded a chemical composition high in stearic acid and low in oleic acid. Both Samples D and E had identical decomposition intervals and similar chemical compositions. Minor differences in the fatty acid composition may have been due to slight variations in the fatty acid content of the original adipose tissue of each pig or particular factors present in the surrounding decomposition environments.

Figure 3 plots the relative concentration of Samples C, D, and E and demonstrates the similarities in fatty acid composition between

the samples. When compared with Fig. 2, higher concentrations of saturated fatty acids (i.e., palmitic and stearic acids) and reduced concentrations of unsaturated fatty acids are evident. As depicted in Fig. 1, the process of decomposition has converted the unsaturated fatty acids to their respective saturated fatty acids. However, the excess stearic acid indicates that the β-oxidation step, which is thought to convert stearic acid to palmitic acid (20), has not yet occurred. This stage of formation is characterized by high concentrations of stearic acid and lower concentrations of unsaturated fatty acids.

The final stage of adipocere formation identified in this study is the advanced stage in which high concentrations of saturated fatty acids are observed. By this stage, the concentration of oleic acid will be considerably reduced, and palmitoleic and linoleic acid should be absent. The relative concentration of palmitic acid should represent more than half the total fatty acid composition.

Sample F was an adipocere sample collected from the cadaver of a decomposed pig after approximately eight months. High levels of palmitic acid were present, while the stearic acid level had reduced, presumably following a β-oxidation step. The level of oleic acid was still relatively high in this sample when compared with the other samples in the category. As the distinction between stages is not precise, this sample could possibly have been classed in the intermediate stage of formation. For this study, however, Sample F was placed in the category representing advanced-stage adipocere formation based on its concentration of palmitic acid, which represented more than half the total fatty acid concentration.

Sample G was also an adipocere sample collected from the cadaver of a pig that had decomposed for eight months. The chemical composition was similar to Sample F but with a slight reduction in oleic acid concentration and a resultant increase in the stearic acid concentration. Both samples had identical decomposition intervals and the minor differences in composition may be due to variations in fatty acid content of the original adipose tissue of each pig. Additionally, factors present in the decomposition environment may have enhanced adipocere formation in Sample G.

An adipocere sample was collected from Sample H that had a decomposition interval of 13 months. Saturated fatty acids accounted for more than 95% of the total fatty acid concentration and the palmitic acid concentration contributed to more than half of the total concentration. The chemical composition suggested that the sample was in an advanced stage of adipocere formation. When compared with Samples A and B, which had identical decomposition intervals, Sample H had undergone more extensive decomposition and had a much more advanced chemical composition. The difference in chemical composition may be due to the fact that Samples A and B were extracted from soil, rather than being directly sampled from the cadaver. It is possible that the leaching effect of soil causes the chemical composition to alter and the formation of adipocere to be retarded. This possibility is further supported by the chemical compositions of Samples D and E, which had the longest decomposition intervals in the study but were only found to be in an intermediate stage of formation. These results demonstrate that the stage of adipocere formation does not directly correlate to the decomposition interval and that the formation of adipocere must have been affected by factors present in the decomposition environment.

Samples I and J were adipocere samples that demonstrated almost identical chemical compositions even though the decomposition interval varied by two months. Both samples were classed as being in an advanced stage of formation based on their dominant saturated fatty acid concentrations. Adipocere is believed to be stable once all of the unsaturated fatty acids have converted to saturated fatty acids (21). As only approximately 5–6% of the relative concentration of Samples I and J contained unsaturated fatty acids, it appeared that the conversion process to adipocere was nearing completion when these samples were collected.

Figure 4 plots the relative fatty acid concentration for Samples F–J and demonstrates the similar trends exhibited for each sample. The concentration of palmitic acid was similar between samples as demonstrated by the overlap of the graphs in that region. With the exception of Sample F (which could have been classed in the intermediate to advanced stage), the concentration of stearic and oleic acids was also comparable between samples. This stage of formation was classified by high saturated fatty acid concentrations and chemical compositions that were close to being stable.

The chemical composition of Sample I further demonstrated that adipocere composition cannot be directly linked to decomposition interval in this study. When compared with Sample C, which had a decomposition interval of 5 months, Sample I had formed a more advanced adipocere product although the decomposition interval

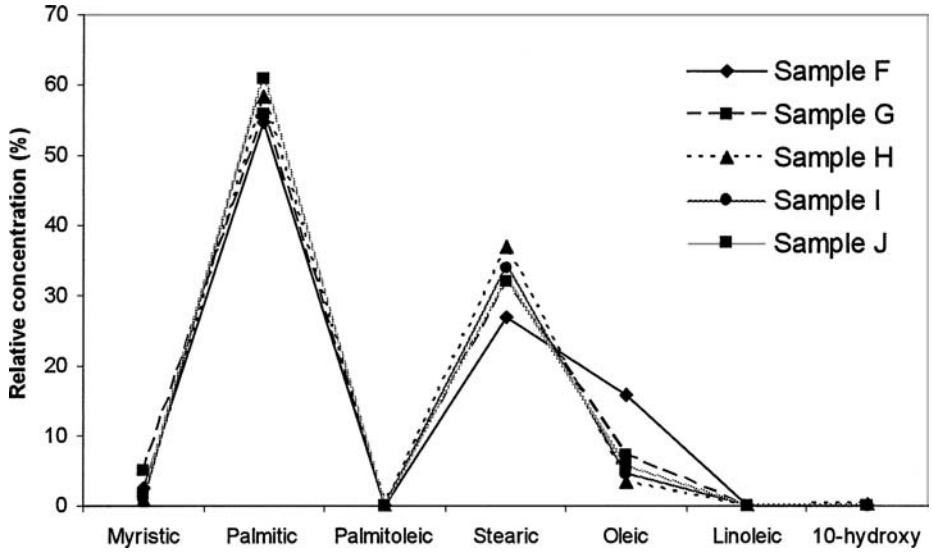

FIG. 4—*Comparison of fatty acid composition in advanced stage adipocere formation.*

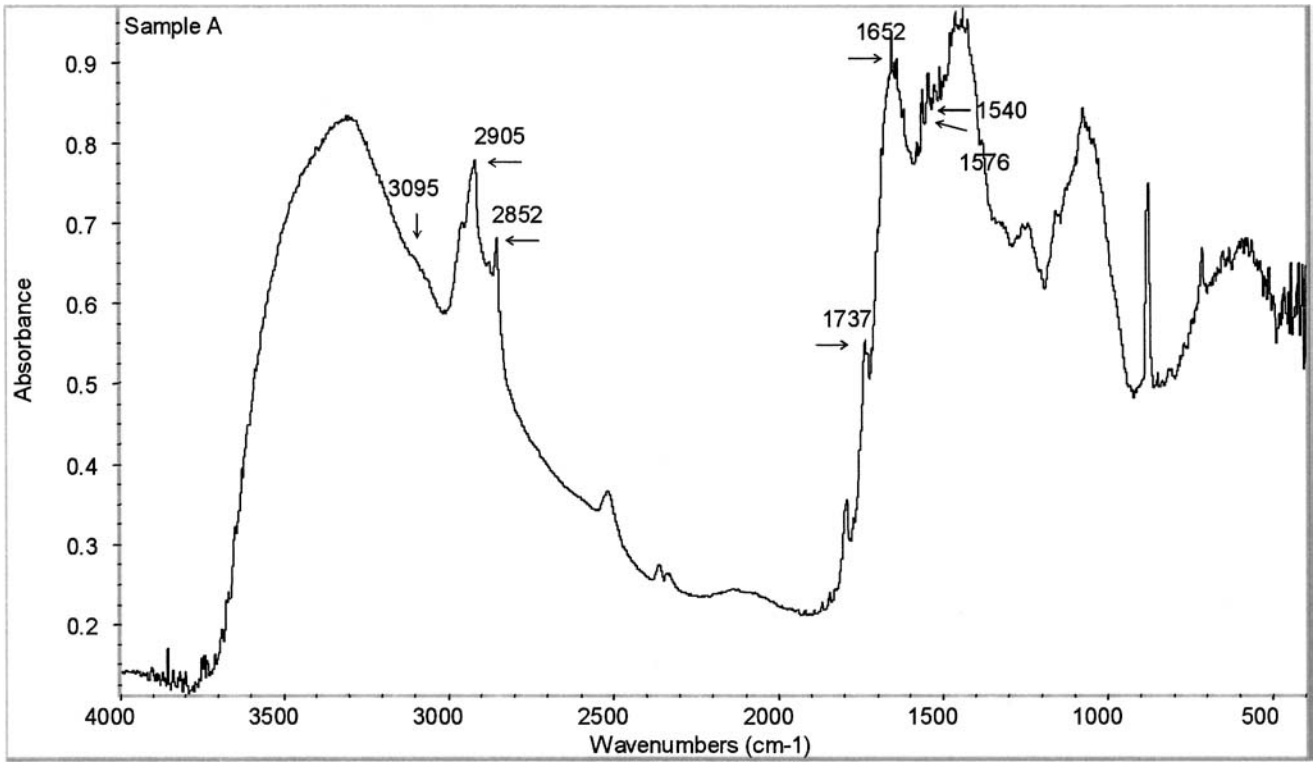

FIG. 5—*Infrared spectrum characteristic of early-stage adipocere formation (relevant peaks are assigned by arrows and wavenumbers).*

TABLE 2—*Major infrared modes of adipocere (17,22).*

Wave Number (cm^{-1})	Assignment
3100–3000	=C–H stretching
2950–2800	C–H stretching
2670–2660	fatty acid O–H stretching
1740–1710	triacylglycerol C=O stretching
1702	fatty acid C=O stretching
1680–1600	C=C stretching
1576	fatty acid calcium salt carboxylate C–O stretching
1540	fatty acid calcium salt carboxylate C–O stretching
1400–1200	lipid CH_2 wagging
1200–1000	lipid CO–O–C stretching
1000–800	C–H bending
800–700	lipid CH_2 rocking

differed by only a month. It was not likely that an additional month decomposition would cause such a large difference in chemical composition, and hence it appeared that factors present in the decomposition environment must have influenced the rate and degree of formation for both samples. Similarly, Sample H had a much more extended decomposition interval than Samples G, I, and J, yet all samples demonstrated similar chemical compositions. Clearly, some additional factors must have been present which affected the adipocere formation process.

FTIR Analysis

The FTIR analysis further confirmed the presence of fatty acids within the samples and identified additional components which were not identified using GC/MS. An infrared spectrum for each stage of formation has been included to further demonstrate the process of adipocere formation. The spectral bands for the major components identified are listed in Table 2.

Figure 5 illustrates the infrared spectrum of Sample A and is characteristic of early-stage adipocere formation. The spectrum showed a small peak at 1737 cm^{-1} attributable to triglycerides still present within the sample due to the lack of decomposition that had occurred. Characteristic modes attributable to unsaturated fatty acids can be seen by the weak shoulder at 3095 cm^{-1} and the stronger peak at 1652 cm^{-1}. Calcium salts of fatty acids were identified by the peaks at 1576 cm^{-1} and 1540 cm^{-1}. The adipocere in Sample A was present in the soil matrix, thus explaining the weak absorbance of the adipocere peaks.

Figure 6 illustrates the infrared spectrum of Sample C and is characteristic of those samples in an intermediate stage of adipocere formation. Triglycerides were still present in small amounts, characterized by the band at wavenumber 1736 cm^{-1}, while unsaturated fatty acids were demonstrated by weak peaks at 3087 cm^{-1} and 1653 cm^{-1}. The abundance of fatty acids was much greater as demonstrated by the fatty acid bands in the region 2950–2800 cm^{-1} and was most likely due to the increase in saturated fatty acids observed in these samples. The modes attributable to calcium salts of fatty acids appear at 1576 cm^{-1} and 1540 cm^{-1}.

The infrared spectrum of Sample J, which is characteristic of those samples in a more advanced stage of adipocere formation, is illustrated in Fig. 7. The most obvious difference between this spectrum and those shown in Figs. 5 and 6 is the disappearance of peaks attributable to both triglycerides and unsaturated fatty acids. The prominent carboxylic acid carbonyl stretching mode at 1702 cm^{-1} can be attributed to saturated fatty acids. Further confirmation of the presence of fatty acids can be seen in the region 2950–2800 cm^{-1}.

The FTIR analysis not only confirmed the presence of triglycerides and fatty acids, but also the conversion of one to the other. The spectra demonstrated a definite decrease in the intensities of the triglyceride and unsaturated fatty acid peaks, and an increase in the intensities of the saturated fatty acid peaks for samples with more extensive adipocere formation. The technique was also useful

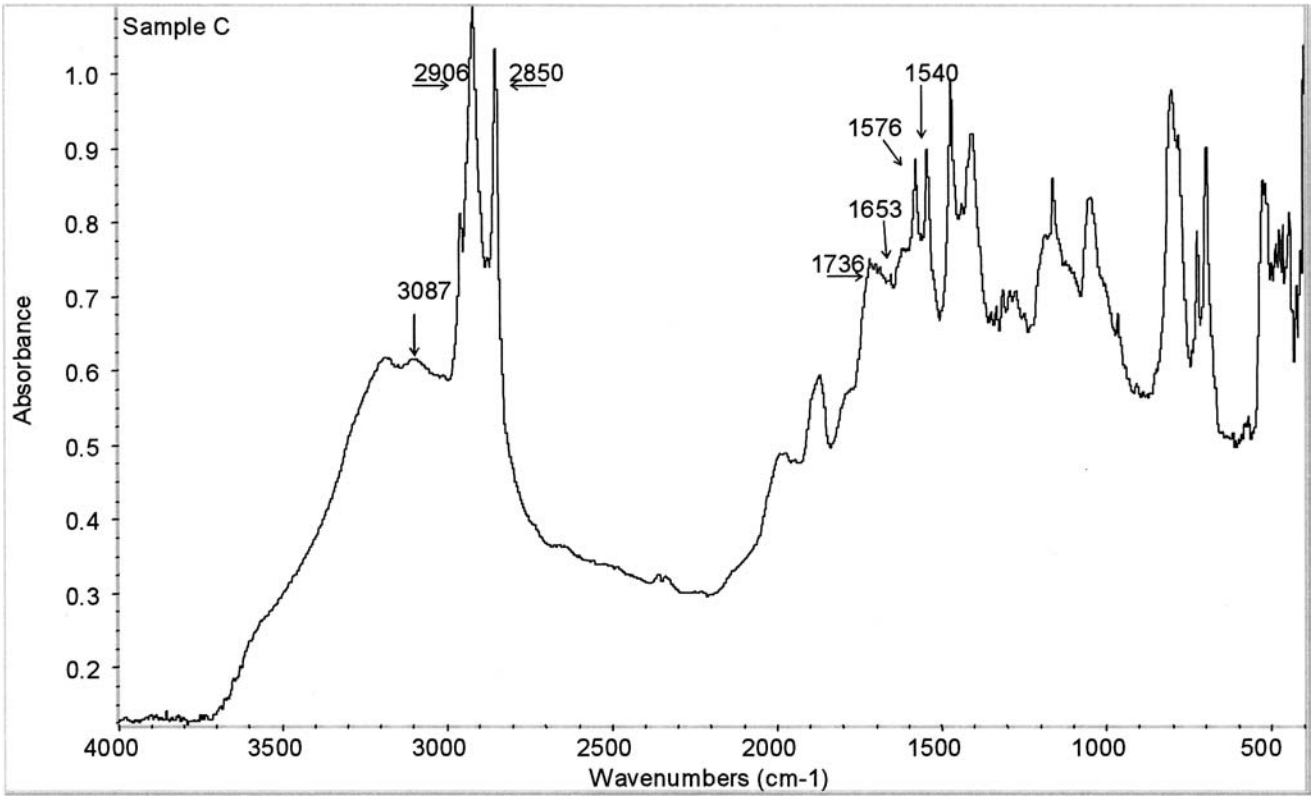

FIG. 6—*Infrared spectrum characteristic of intermediate stage adipocere formation (relevant peaks are assigned by arrows and wavenumbers).*

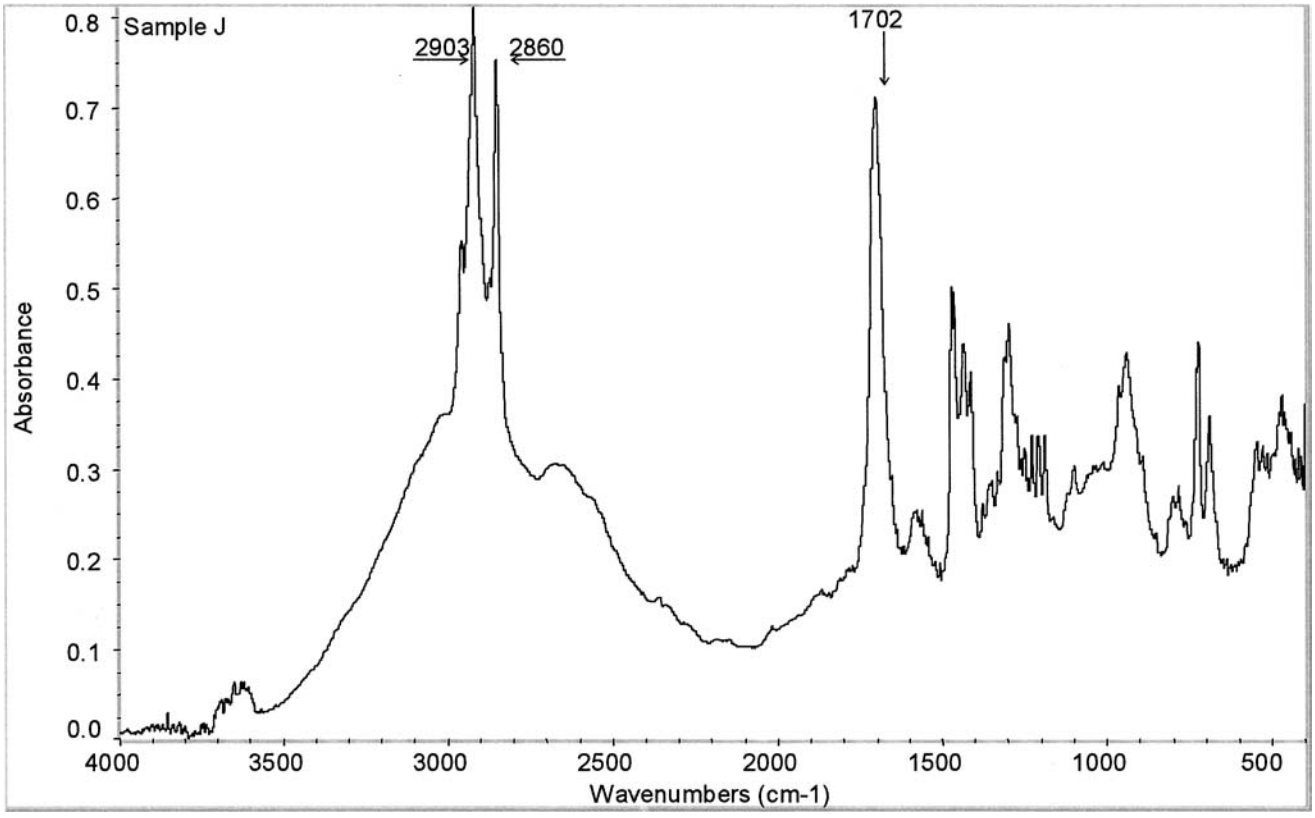

FIG. 7—*Infrared spectrum characteristic of advanced stage adipocere formation (relevant peaks are assigned by arrows and wavenumbers).*

for identifying calcium salts of fatty acids which are not identifiable by GC/MS.

Discussion

The study aimed to demonstrate the chemical conversion of adipose tissue to the decomposition product, adipocere. Using GC/MS and FTIR spectroscopy it was possible to show the various stages (as identified in this study) through which the process passes. Figure 1 outlined the chemical conversion and Table 1, combined with the infrared spectra, supported the outline. As decomposition proceeded, the triglycerides present in the original adipose tissue hydrolyzed and their concentrations decreased as evidenced in the three infrared spectra outlined in Figs. 5, 6, and 7. Unsaturated and saturated fatty acids were released and the chemical composition of the early-stage adipocere samples reflected this release. Figure 2 demonstrated an initial decrease in unsaturated fatty acids with a subsequent increase in palmitic acid. Figure 3 showed a further decrease in unsaturated fatty acids and a notable increase in the concentration of stearic acid. Figure 4 demonstrated the final stages of formation with negligible unsaturated fatty acids remaining and high concentrations of saturated fatty acids. The infrared spectra also followed this pattern, thus confirming the general process of adipocere formation observed in this study.

One of the interesting results of the study was the lack of correlation between the stage of adipocere formation and the decomposition interval. It was initially assumed that a longer decomposition interval would result in an adipocere product with an advanced and stable chemical composition. However, the lack of correlation suggests that the process of adipocere formation is affected by factors other than decomposition interval and that these factors are most likely present in the decomposition environment. Consequently, studies need to be conducted which investigate the various factors present in a decomposition environment, and their effect on adipocere formation. Once the effect of particular factors on adipocere formation are known and can be accounted for, a correlation between decomposition interval and adipocere formation may be determined. The authors did not have the option, in this preliminary study, to control the variables that are thought to affect adipocere formation and as a result have commenced studies to investigate the factors present in a burial environment, including temperature, moisture, pH, clothing, and soil type. The studies will control the individual variables so as to determine their effect on adipocere formation.

A further result of the study was the intimation that adipocere which had leached into the surrounding soil generally showed a chemical composition much less advanced than the composition of adipocere sampled directly from the cadaver. As only a minimal number of samples were analyzed in this study, it cannot be determined conclusively whether the leaching of adipocere had any affect on the formation process. However, the preliminary results suggest that adipocere formation may be retarded when it leaches into soils as compared with adipocere which forms directly on a cadaver. Gill-King (4) proposed that the slowing of saponification in soils with high redox potentials is due to the reduction in availability of unsaturated fatty acids by auto-oxidation. The authors recommend that further research should be conducted using a larger sample group to determine whether the results identified in this study can be replicated.

The study reported here acts as a preliminary investigation into the stages of adipocere formation and the chemical process by which it forms in soils. While the conversion process of adipocere has been well documented, few studies have been able to chemically demonstrate the process of formation. The study was useful in showing that adipocere formation is affected by factors other than decomposition interval and that a stage of formation cannot be directly linked to the decomposition interval unless the effect of these particular factors is known. Recommendations for future work included the investigation of factors associated with a burial environment and the effect of leaching on adipocere formation.

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