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# Seasonal Variations in the Calorific Values of Mangrove Plants of the Saudi Arabian Red Sea Coast

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ABSTRACT. The calorific values of *Avicennia marina*, by using a phillipson type electronic microbomb calorimeter (model AH 12/EF) was made for material of *A. marina* mangrove collected monthly (Jan.-June 1986) from Dhahban about 50 km north of Jeddah; and for material collected in Feb. 1986 from Al-Wajh and Jizan located at North and South of the Saudi Red Sea Coast.

Results of this study elucidate that :

1. The highest calorific values for seeds and leaves was recorded in Jan., and Feb. and this period was the beginning of fruiting season where the seeds and leaves were young and healthy and very green in colour, while in June (the end of fruiting season) where most seeds and leaves were mature and ripe, the calorific values were lower.
2. Always, the young seeds and leaves have higher calorific value than the mature ones, which mean that the young seeds and leaves contain more of oxidisable materials, however, pneumatophores did not show this pattern.
3. The calorific values of the seeds are usually higher than those of the leaves or the pneumatophores.
4. Plants of *A. marina* collected from Jizan showed higher calorific values than plants collected from Al-Wajh, and Dhahban. This may be related to the healthy growth of Jizan material, where the soil is relatively, containing high organic matter.
5. There is no relation between the calorific values and the ash-free organic matter which means that not all the ash-free organic matter content is oxidisable.

## Introduction

Previous studies of nutritive value of the mangrove plants of Saudi Arabia have shown some significant differences in their content, Krishnamurthy[1] and Khafaji *et al.*[2]. For this reason, it was decided to study the energy stored in the biomass in the form of oxidisable chemical compounds in the cell wall and cell contents, *i.e.*, to study the calorific values of these plants. This is possible, because the oxidisable material can be converted into heat and expressed in energy units (calories and kilo calories). Calorimetry has been in use by many investigators, namely Wort[3], Golley[4,5], Slobodkin and Richman[6], Bliss[7], Phillipson[8], Kendeigh and West[9], Nakamura[10], Klekowski *et al.*[11], Paine and Vadas[12], Boyd[13], Paine[14], Armando and Gabriel[15], Prus[16], Himmelman and Carefoot[17], Btreon-Provencher and Cardinal[18], McQuaid[19], and many others. Previous studies of calorific values of plant materials have led to the development of different calorimetric methods to measure such values. For example Paine[14] stated that there are at least four procedures that could permit evaluations of an organisms heat content. Kendeigh and West[19], who studied the calorific values of 5 species of seeds, have used a parr No. 1211 adiabatic oxygen bomb calorimeter.

However, Paine and Vadas[12], who studied the calorific values of over 70 macroscopic benthic algae, have used a Parr semi-micro oxygen bomb calorimeter (model 1411).

Phillipson[8] described a new miniature Calorimeter which was capable of combusting samples from 5-100 mg.

Most of the previous studies discussed microorganisms, however, few studies were dealt with higher plants. For example, Armando & Gabriel[15] studied the caloric changes in *Juncus roemeranus* leaves by using an automatic Parr adiabatic bomb calorimeter. Also Bliss[7] studied the caloric content of *Alpine* Tundra plants. The vascular aquatic macrophyte *(Typha latifolia)* has been studied by Boyd[13]. Few authors studied the seasonal variation in the calorific content. For example, Golley[5] made an extensive studies of over 600 records of plants and animals. He found significant differences between different parts of plants, between vegetation collected in different seasons and between vegetation from different communities.

The mangrove plants are very abundant alongside the Red Sea coast of Saudi Arabia which consist mainly of *A. marina* and few localities have *Rhizophora mucronata* plants; Migahid[20], Zahran[21], Zahran *et al.*[22], and Mandura *et al.*[23]. These mangrove plants have many economic values, *e.g.* their leaves can be eaten by animals (Camels, sheep, ... etc.); Hamilton & Snedaker[24] and Kehar & Negi[25]. Although these mangrove plants are economically important, yet nothing is known about their calorific values of the species inhabiting the Saudi Red Sea coast.

The present paper presents an attempt to study the seasonal variation in the calorific values of *A. marina* from Dhahban 50 km north of Jeddah, also variation in Calorific values of different parts of *A. Marina* collected from another two mangrove swamps of the Saudi Red Sea coast, namely, Jizan and Al-Wajh, 600 km south and north of Jeddah respectively, were determined.

## Material and Methods

Plants of *Avicennia marina* were collected monthly (Jan.-June 1986) from Dhahban 50 km north of Jeddah, Saudi Arabia. Also plants were collected in February 1986 from Jizan about 600 km south of Jeddah (Lat 16.55 N, long. 42.96 E) and from Al-Wajh about 600 km north of Jeddah (Lat 26.13 N, long 36.26 E). After collection, plants were thoroughly washed with distilled water to remove any sediments and adhering detritus. The plants were then sorted into leaves, seeds and pneumatophores, furthermore the seeds and leaves were sorted into various sizes, as shown in Fig. 1a & b, then they were dried at 50-70°C in air dried oven for 24 hours.

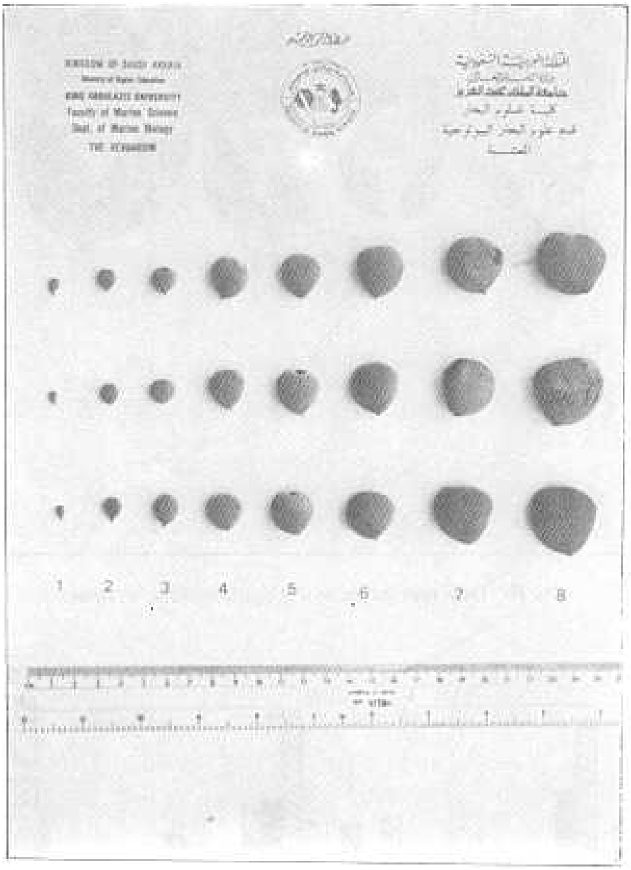
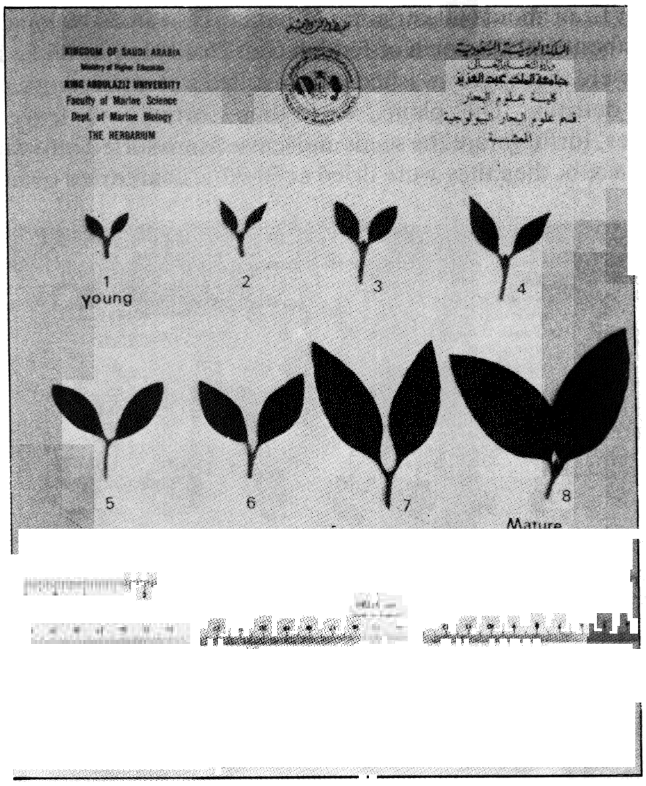



FIG. 1a. Different stages of seed maturity of *A. marina*.

The dried materials were then ground and stored in a desiccator to be used for combustion in the philippson type electronic microbomb calorimeter (model AH 12/EF)[8]. For calibration, a series of pellets of pure dry benzoic acid varying in weight from 5-20 mg were used to provide a number of different points. A calibration line was then obtained by plotting the heat output from the calorimeter against the weight of the benzoic acid oxidized. By using the calibration line, the amount of heat can be converted into calories.



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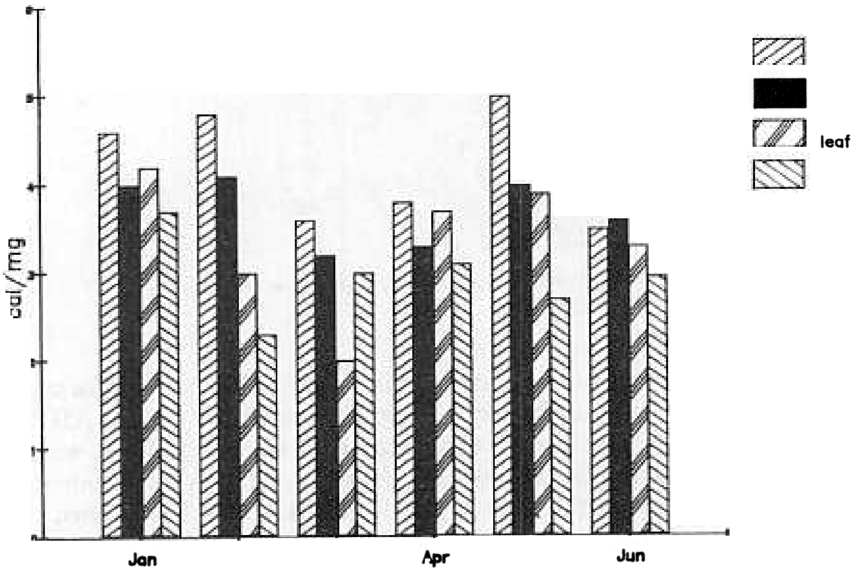

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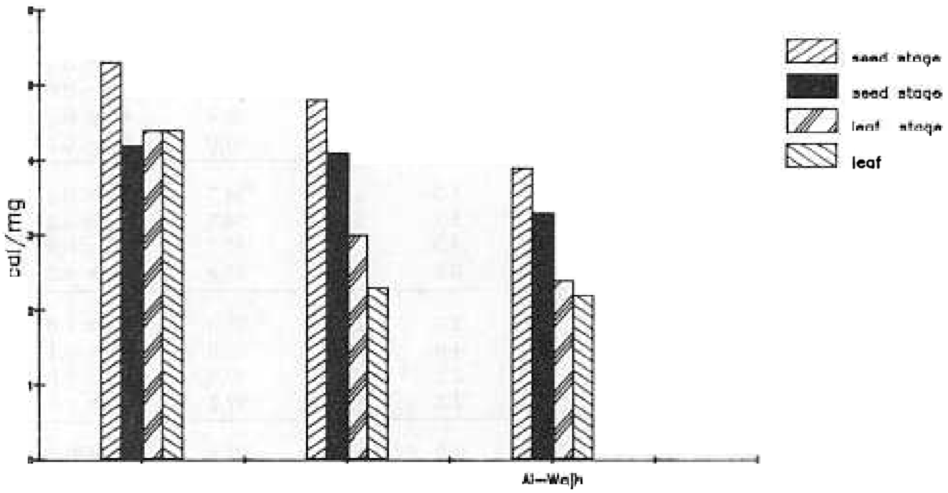


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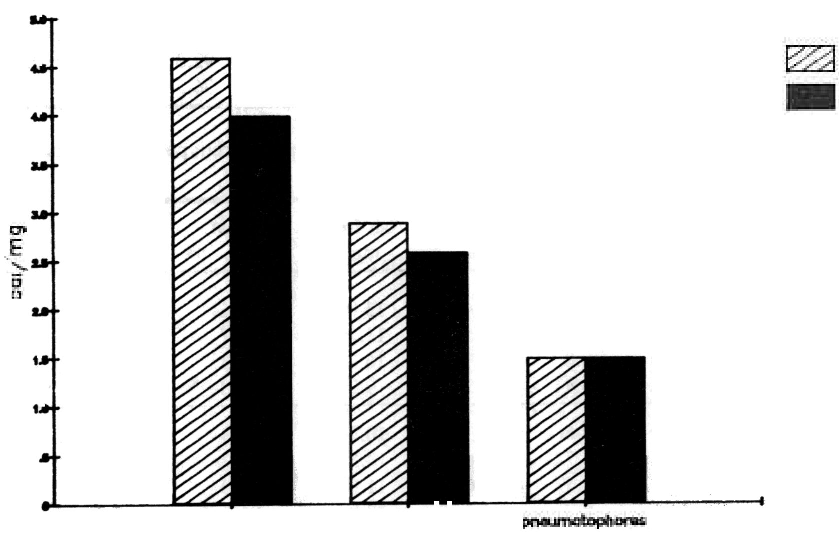


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TABLE 1. Calorific values of *Avicennia marina* collected from Dhahban at different times of the year.

| Date | Material | | Dry wt. mg | Ash mg | wt. % | Ash-free mg | Dry wt. % | Cal./mg$^{-1}$ mean ± S.D |
|---|---|---|---|---|---|---|---|---|
| Jan. | Seed | stage | (1) 12.0 | 0.7 | 5.8 | 11.3 | 94.2 | 4.6 ± 0.1 |
| 1986 | „ | „ | (8) 14.6 | 0.6 | 4.2 | 14.0 | 95.8 | 4.0 ± 0.0 |
| | Leaves | „ | (1) 13.0 | 0.6 | 4.6 | 12.4 | 95.4 | 4.2 ± 0.1 |
| | „ | „ | (8) 10.1 | 0.5 | 5.0 | 9.6 | 95.0 | 3.7 ± 0.2 |
| Feb. | Seed | stage | (1) 11.3 | 0.6 | 5.3 | 10.7 | 94.7 | 4.8 × 0.2 |
| 1986 | „ | „ | (8) 15.2 | 0.8 | 5.3 | 14.6 | 94.7 | 4.0 ± 0.2 |
| | Leaves | „ | (1) 9.3 | 0.4 | 4.3 | 8.9 | 95.7 | 3.0 ± 0.0 |
| | „ | „ | (8) 10.1 | 0.5 | 0.5 | 9.6 | 95.0 | 3.6 ± 0.2 |
| Mar. | Seed | stage | (1) 12.0 | 0.6 | 5.0 | 11.4 | 95.0 | 3.2 ± 1.0 |
| 1986 | „ | „ | (8) 9.9 | 0.4 | 4.0 | 9.5 | 95.0 | 2.0 ± 0.1 |
| | Leaves | „ | (1) 14.1 | 0.3 | 2.1 | 13.8 | 97.9 | 3.0 ± 0.0 |
| | „ | „ | (8) 10.9 | 0.3 | 2.8 | 10.6 | 97.2 | 3.8 ± 1.0 |
| Apr. | Seed | stage | (1) 19.5 | 1.4 | 7.2 | 18.1 | 92.8 | 3.3 ± 0.2 |
| 1986 | „ | „ | (8) 8.5 | 0.5 | 5.9 | 8.0 | 94.1 | 3.7 ± 0.3 |
| | Leaves | „ | (1) 11.7 | 0.7 | 6.0 | 11.0 | 94.0 | 3.1 ± 0.1 |
| | „ | „ | (8) 10.2 | 0.8 | 7.8 | 9.4 | 92.2 | 5.0 ± 1.0 |
| May. | Seed | stage | (1) 11.8 | 1.4 | 11.9 | 10.4 | 89.1 | 4.1 ± 0.1 |
| 1986 | „ | „ | (8) 16.5 | 1.0 | 6.05 | 15.5 | 97.0 | 3.9 ± 0.1 |
| | Leaves | „ | (1) 11.7 | 0.7 | 6.0 | 11.0 | 94.0 | 2.7 ± 0.3 |
| | „ | „ | (8) 12.3 | 0.7 | 5.7 | 11.6 | 94.3 | 3.5 ± 0.0 |
| June | Seed | stage | (1) 11.6 | 0.5 | 4.3 | 11.1 | 95.7 | 3.6 ± 0.0 |
| 1986 | „ | „ | (8) 9.5 | 0.4 | 4.2 | 9.1 | 95.8 | 3.3 ± 0.0 |
| | Leaves | „ | (1) 13.0 | 1.0 | 7.7 | 12.0 | 92.3 | 3.0 ± 0.1 |
| | „ | „ | (8) 11.6 | 0.4 | 3.5 | 11.2 | 96.5 | 5.3 ± 0.1 |

TABLE 2. Calorific values of *Avicennia* collected in February 1986 from different parts of the Saudi Red Sea coast.

| Material | | Dry wt. mg | Ash mg | wt. % | Ash-free mg | Dry wt. % | Cal./mg$^{-1}$ |
|---|---|---|---|---|---|---|---|
| Seed | Stage | (1) 13.6 | 0.6 | 4.4 | 13.0 | 95.6 | 5.3 ± 1.0 |
| „ | „ | (8) 11.8 | 0.5 | 0.5 | 11.2 | 95.7 | 4.2 ± 1.0 |
| Leaves | „ | (1) 17.0 | 0.8 | 4.7 | 16.2 | 95.3 | 4.4 ± 3.0 |
| „ | „ | (8) 9.6 | 0.4 | 4.2 | 9.2 | 95.8 | 4.1 ± 0.7 |
| Seed | Stage | (1) 11.3 | 0.6 | 5.3 | 10.7 | 85.8 | 4.8 ± 0.2 |
| „ | „ | (8) 15.2 | 0.7 | 4.6 | 14.5 | 98.7 | 4.1 ± 0.1 |
| Leaves | „ | (1) 12.3 | 0.5 | 4.0 | 11.8 | 96.0 | 3.0 ± 0.0 |
| „ | „ | (8) 14.6 | 0.7 | 4.8 | 13.9 | 95.2 | 2.3 ± 1.0 |
| Seed | Stage | (1) 12.3 | 0.6 | 4.9 | 11.7 | 97.6 | 3.9 ± 0.3 |
| „ | „ | (8) 12.0 | 0.6 | 5.0 | 11.7 | 97.5 | 3.3 ± 0.2 |
| Leaves | „ | (1) 15.6 | 0.8 | 5.1 | 15.4 | 98.7 | 2.4 ± 0.1 |
| „ | „ | (8) 13.2 | 0.4 | 3.0 | 12.8 | 97.0 | 2.2 ± 0.3 |

TABLE 3. Calorific values of different parts of *A. marina* collected from Dahaban.

| Part of of plant | Material | Dry wt. mg | Ash wt. mg | Ash-free % | dry wt. mg | Cal./mg$^{-1}$ % | |
|---|---|---|---|---|---|---|---|
| Leaves | Young | | | 8.1 | 6.8 | 91.9 | 2.9 ± 0.1 |
| | Mature | | | 7.4 | 7.5 | 92.6 | 2.6 ± 0.0 |
| Seed | Young | 11.3 | 0.8 | 7.0 | 10.5 | 93.0 | |
| | Mature | 8.0 | 0.4 | 5.0 | 7.6 | 95.0 | |
| Pneuma-tophore | Young | 8.0 | 1.0 | 12.5 | 7.0 | 87.5 | 1.5 ± 0.3 |
| | Mature | 13.1 | 1.6 | 12.2 | 11.5 | 87.8 | 1.5 ± 0.1 |

Measurements of three samples gave standard errors of 0.0-2.0%; sometimes it was necessary to repeat the odd measurement. Results are summarized in Tables 1-3 and in Figs. 2-4.

## Results and Discussion

Results are presented in Tables 1-3 and in three histograms, Fig. 2-4. In general, results show that the calorific values of the different parts of *Avicennia* plants of Dahaban coast varied from month to month. Also, there was variation between the calorific values of the mangrove plants collected from Jizan and Al-Wajh.

As shown in Fig. 2, the highest calorific values for seeds were recorded in January and February, and this was the beginning of fruiting season, where the seeds are healthy and very green in colour, while in June, the calorific values were very low because it was the end of fruiting season and most seeds were mature and ripe.

Also, Fig. 2 shows that the measurements of calorific values of both seeds and leaves of *Avicennia* commenced in January which is the beginning of fruiting season and end in June which is the end of the fruiting season. This figure shows that the highest calorific values of both seeds and leaves were recorded in January when plants grow healthy and green because of lower temperature and higher amount of rain.

Figure 3 shows that, in both seeds and leaves, the young ones, always have higher calorific values which can be related to the lower percentage of ash in the young seeds and leaves which mean that the young seeds and leaves contain more of the oxidisable materials. However, pneumatophore did not show this pattern, *i.e.* both the young and mature ones have similar calorific values. This figure also shows that seeds in all cases have higher calorific values than leaves and pneumatophores which has the least value, this can be explained as a result of increase in lipid content; this result agreed with Bliss[7] and Boyd[13] who found that calorific values fluctuated with variation in lipid and protein concentration.

In Fig. 4, both the seeds and leaves showed higher calorific content when plants collected from Jizan with same pattern again, *i.e.* young ones have higher calorific values than the mature ones. These results can be related to the healthy growth of Jizan material, where the soil is more organic and humid. An interesting result was obtained, that the calorific values do not always correlate with the percentage of ash-free content, which perhaps means that not all the ash-free content (Tables 1-3) is oxidisable and, hence, can be converted to energy.

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# الاختلافات الموسمية في القيم السُّعرية لنباتات المانجروف النامية على شاطئ البحر الأحمر ، المملكة العربية السعودية

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درست القيم السعرية لنبات المانجروف (أفيسنيا مارينا) باستعمال المسعِّر نموذج فليبسون الإلكتروني (طراز AH 12/EF ) على نباتات جمعت بصورة شهرية (يناير - يونيو ١٩٨٦م) من منطقة دَهَبَان (حوالي ٥٠ كيلومتراً شمال جدة) وكذلك على نباتات جمعت في شهر فبراير ١٩٨٦م من منطقتى جيزان والوجه (حوالي ٦٠٠ كم جنوب وشمال جدة على التوالي) .

وقد أوضحت النتائج ما يلي :

١ - أعلى قيمة سُعرية للبذور والأوراق سُجلت بين شهري يناير وفبراير ، وهو وقت بداية موسم الإثمار ، وكانت البذور والأوراق بالتالي صغيرة ومزدهرة وشديدة الخضرة ، بينما سُجلت أقل قيمة سعرية في شهر يونيو ، (نهاية موسم الإثمار) حين كانت معظم البذور والأوراق كبيرة وناضجة .

٢ - سَجلت البـذور والأوراق الصغيرة قيمة سعرية أعلى من البـذور والأوراق الناضجة ، ويعني هذا أن البذور والأوراق الصغيرة تحتوى على مواد قابلة للتأكسد أكثر ، أما الجذور التنفسية للنبات فلم تُبْد هذه العلاقة ، إذ كانت الجذور التنفسية الصغيرة والكبيرة تحتوى على قيم سعرية متساوية .

٣ - تحتوى البذور على قيم سعرية أعلى مما في الأوراق أو الجذور التنفسية ، وهذا نتيجة لزيادة المحتوى الدهني في البذور عن الأوراق والجذور التنفسية .

٤ - أظهر نبات الأفيسنيا مارينا ، الذي جمع من منطقة جيزان ، قيماً سعرية أعلى من النباتات التي جمعت من الوجه أو دهبان . وربما يرجع ذلك إلى النمو الصحي لنباتات جيزان إذ إن التربة أكثر رطوبة وأكثر عضوية عنه في المناطق الشمالية .

٥ - أوضحت النتائج أن المحتوى العضوي الخالي من الرماد يرتبط دائماً مع القيم السُّعرية ، ويعنى ذلك أن المادة العضوية ليست كلها قابلة للتأكسد في تلك النباتات .