

# The Study of Total Organic Carbon Content (TOC) In Various Natural Charcoals

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## ABSTRACT:

The review study presented in this abstract investigates the total organic carbon (TOC) content in different natural charcoals obtained from diverse sources. Charcoal, a carbon-rich material produced through the pyrolysis of organic matter, plays a significant role in various applications, including soil improvement, water purification, and carbon sequestration. Understanding the TOC content of different charcoals is essential for evaluating their suitability in these applications and assessing their potential environmental impacts. To achieve this, a comprehensive analysis was conducted on charcoals derived from various natural sources, such as wood, food shells residues. Samples were collected from different geographic regions to capture variations in TOC content influenced by local climate, vegetation, harvest and production methods. The TOC analysis was carried out using established laboratory techniques, including combustion and spectroscopy methods. The results of this study revealed significant variations in TOC content among the different natural charcoals. Charcoals derived from wood and food waste shells, such as coconut and pista shells and lemon wood exhibited higher TOC content compared to those from softwoods or agricultural residues. Additionally, the carbonation process and production conditions played a crucial role in determining TOC content, with higher temperatures leading to decreased TOC levels. The findings of this research have implications for the selection and application of natural charcoals in various fields. Charcoals with higher TOC content may be more suitable for soil improvement and carbon sequestration efforts, while those with lower TOC content could find applications in water purification or as fuel sources. Furthermore, understanding the regional variations in TOC

content can help optimize charcoal production processes and minimize environmental impacts. In conclusion, this study provides valuable insights into the TOC content of different natural charcoals, highlighting the need for careful consideration when choosing charcoal sources for specific applications. It also underscores the importance of sustainable charcoal production practices to mitigate the environmental consequences associated with charcoal production.

**Key words:** Natural charcoals, TOC, wood and food waste, environmental impacts

## I. INTRODUCTION:

Charcoal, a carbon-rich material produced through the pyrolysis of organic matter, has a wide range of applications, including soil improvement, water purification, and carbon sequestration. It is an essential component in various industries and environmental initiatives. The total organic carbon (TOC) content in charcoal can vary significantly based on the source material, production methods, and geographic location. This variability in TOC content is of utmost importance in determining the suitability of charcoal for different applications and understanding its environmental impact. In this study, we focus on the analysis of TOC content in natural charcoals derived from four distinct sources: coconut shells, lemon wood, and pista (pistachio) shells. Each of these sources represents different organic materials, properties and uses and geographic regions, which can contribute to variations in TOC content. Understanding the TOC content of charcoals obtained from these sources is crucial for assessing their potential applications and environmental implications.

Coconut shells, a common source of charcoal in tropical regions, are known for their

high carbon content and durability. Lemon wood, on the other hand, is a hardwood often used for charcoal production, and its TOC content may differ from that of coconut shells. Pista shells, a waste product from the pistachio industry, present an environmentally friendly opportunity for charcoal production each charcoal having own properties and common uses, but their TOC content remains largely unexplored. This research aims to provide a comprehensive analysis of the TOC content in charcoals from these diverse sources. By analyzing the TOC content, we can determine the carbon sequestration potential of these charcoals, their suitability for improving soil fertility, and their effectiveness in water purification applications. Additionally, this study will shed light on the environmental sustainability of using waste materials, such as pista shells, for charcoal production. The findings of this research will contribute to the understanding of how different natural charcoals can be utilized in various industries and environmental initiatives. Moreover, it will emphasize the importance of considering TOC content when selecting charcoal sources for specific applications, promoting sustainable practices in charcoal production, and reducing the environmental impact associated with charcoal production processes.

### **Properties and uses of natural wood and food waste Charcoals**

#### **Coconut Shell Charcoal properties and uses**

Coconut shell charcoal is a type of charcoal produced from the shells of coconuts. It is a popular and versatile form of charcoal due to its unique properties and wide range of uses. Here are some of its key properties and common applications:

**High Carbon Content:** Coconut shell charcoal typically has a high carbon content, making it an excellent source of clean and efficient energy when burned.

**Low Ash Content:** It produces relatively low ash compared to other types of charcoal, which means less residue and easier cleanup.

**Low Moisture Content:** Coconut shell charcoal is usually dried thoroughly during the production process, resulting in a low moisture content. This contributes to its high energy density.

**Long-Lasting Burn:** It has a long burn time and can maintain a consistent heat, making it ideal for cooking and grilling.

**High Heat Output:** Coconut shell charcoal can generate high temperatures, making it suitable for various applications, including industrial processes.

**Lightweight and Easy to Handle:** The lightweight nature of coconut shell charcoal makes it easy to transport and handle.

**Neutral Odor and Taste:** It has a neutral odor and does not impart strong flavors to food, making it suitable for grilling and cooking without affecting the taste of the dishes.

#### **Common Uses of Coconut Shell Charcoal:**

**Cooking and Grilling:** Coconut shell charcoal is widely used as a fuel source for barbecues, grills, and outdoor cooking due to its clean burn and high heat output. It is a popular choice for charcoal grilling enthusiasts.

**Industrial Applications:** Its high heat output and long burn time make coconut shell charcoal suitable for industrial processes such as metal smelting, activated carbon production, and metallurgy.

**Activated Carbon:** Coconut shell charcoal can be processed to create activated carbon, which is used in water purification, air filtration, and the removal of impurities and contaminants from various substances.

**Art and Crafts:** Artists often use coconut shell charcoal for drawing and sketching due to its carbon-rich nature and smooth texture.

**Agriculture:** Coconut shell charcoal can be ground into a fine powder and used as a soil conditioner to improve soil fertility, water retention, and microbial activity.

**Beauty and Cosmetics:** Activated carbon derived from coconut shell charcoal is used in skincare products like facial masks and cleansers for its ability to adsorb impurities and toxins from the skin.

**Odor Control:** Coconut shell charcoal is used in air purifiers, refrigerators, and footwear to absorb and eliminate unpleasant odors.

**Energy Source:** In some regions, coconut shell charcoal is used as a source of household energy for cooking and heating.

Coconut shell charcoal's wide range of applications and its desirable properties make it a valuable commodity in many industries. Its eco-friendly nature, as it is derived from a waste product of coconut processing, adds to its appeal as a sustainable and versatile material.

#### **Pista Shell Charcoal properties and uses:**

Pista shell charcoal, which is charcoal produced from pistachio shells, possesses unique properties and can be used in various applications. Here are some of its key properties and common uses:

#### **Properties of Pista Shell Charcoal:**

**High Carbon Content:** Pista shell charcoal typically contains a high percentage of carbon, which is essential for efficient and clean combustion.

**Low Moisture Content:** It is often dried thoroughly during the production process, resulting in low moisture content, which contributes to its high energy density.

**Low Ash Content:** Pista shell charcoal tends to produce relatively low amounts of ash when burned, which means less residue and easier cleanup.

**Neutral Odor and Taste:** Pista shell charcoal generally has a neutral odor and does not impart strong flavors to food, making it suitable for grilling and cooking without affecting the taste of the dishes.

#### **Common Uses of Pista Shell Charcoal:**

**Cooking and Grilling:** Pista shell charcoal can be used as a fuel source for barbecues, grills, and outdoor cooking. It provides a clean and efficient burn, making it suitable for grilling various foods.

**Industrial Applications:** Due to its high heat output and low ash content, pista shell charcoal can be used in industrial processes that require a reliable and consistent heat source. This includes applications in metallurgy, foundries, and heat-treatment processes.

**Agriculture:** Ground pista shell charcoal can be used as a soil conditioner to improve soil quality. It enhances soil fertility, water retention, and microbial activity, making it beneficial for agricultural applications.

**Activated Carbon Production:** Pista shell charcoal can be processed to create activated carbon, which has applications in water purification, air filtration, and the removal of impurities and contaminants from various substances.

**Art and Craft:** Artists and craftsmen may use pista shell charcoal for drawing and sketching due to its carbon-rich nature and texture.

**Odor Control:** Activated carbon derived from pista shell charcoal can be used in air purifiers, filters, and footwear to absorb and eliminate unpleasant odors.

**Biochar:** Pista shell charcoal can be used as a form of biochar when added to soil. Biochar helps sequester carbon in the soil, enhances soil health, and promotes sustainable agriculture.

**Energy Generation:** In some regions, pista shell charcoal can be used as a source of household energy for cooking and heating.

Pista shell charcoal, like other types of biomass-derived charcoal, offers a sustainable and versatile material for various applications. Its eco-friendly nature, as it is produced from a waste product of the pistachio industry, adds to its appeal as a resource-efficient and environmentally friendly option for charcoal production and other uses.

#### **Lemon wood charcoal properties and uses**

Lemon wood, also known as Citrus limon wood, is a type of hardwood that can be used for charcoal preparation. This natural wood waste material has unique properties and can be utilized for various purposes. Below, I'll discuss the properties and potential uses of lemon wood for charcoal preparation:

#### **Hardness and Density:**

Lemon wood is a hardwood, which means it is typically denser and harder than softwoods. This property can make it suitable for charcoal production as it can yield a substantial amount of carbon-rich material.

#### **Carbon Content:**

Lemon wood, like most hardwoods, contains a high amount of carbon. This is a crucial factor for charcoal production because a higher carbon content contributes to better quality charcoal.

#### **Low Moisture Content:**

For efficient charcoal production, the wood material used should have low moisture content. Lemon wood is known for its relatively low moisture content, which is beneficial in the carbonization process.

#### **Combustion Properties:**

Charcoal produced from lemon wood can have excellent combustion properties. It can burn at high temperatures and produce a long-lasting, consistent heat source, making it valuable for cooking, grilling, and heating applications.

#### **Aromatic Properties:**

Lemon wood can have a pleasant citrus aroma, which can add a unique flavor when used for grilling or smoking foods. This aromatic quality can be desirable in culinary applications.

#### **Sustainability:**

Utilizing lemon wood waste for charcoal production is a sustainable practice, as it repurposes a byproduct of lemon cultivation and reduces waste.

### **Potential Uses:**

**Grilling and Smoking:** Lemon wood charcoal can be used in grills and smokers to impart a citrusy aroma and flavor to grilled meats, fish, and vegetables.

**Cooking Fuel:** Due to its high heat output and long-lasting burn, lemon wood charcoal can serve as a reliable fuel source for cooking in outdoor or indoor settings.

**Art and Craft:** Lemon wood charcoal can be used by artists and craftsmen for drawing and sketching due to its carbon-rich nature.

**Soil Amendment:** Lemon wood charcoal can be added to soil as a biochar to improve soil fertility, water retention, and microbial activity in agricultural applications.

**Water Filtration:** Activated charcoal derived from lemon wood can be used in water filtration systems to remove impurities and contaminants from drinking water.

**Carbon Sequestration:** Lemon wood charcoal, when added to soil, can sequester carbon, contributing to carbon capture and reducing greenhouse gas emissions.

In summary, lemon wood waste has valuable properties that make it suitable for charcoal preparation and various other applications. Its high carbon content, low moisture content, and pleasant aroma make it a versatile material that can be used for grilling, cooking, art, agriculture, and environmental initiatives like carbon sequestration and water filtration. Utilizing lemon wood waste in these ways can contribute to sustainability and reduce the environmental impact of waste disposal.

### **Preparation of charcoals :**

The preparation processes for making charcoal from lemon wood, coconut shells, and pista shells involve several key steps to convert these organic materials into a carbon-rich product suitable for various applications.

#### **Coconut Shell Charcoal:**

The preparation of coconut shell charcoal starts with the collection of coconut shells, typically obtained as a byproduct of coconut processing or from coconut farms. The shells are thoroughly cleaned to remove any remaining coconut meat and husk fibers. Next, the cleaned shells are dried to reduce their moisture content, which is critical for efficient carbonization. The carbonization process, carried out in kilns or retorts, involves heating the dried coconut shells in the absence of oxygen to drive off volatile

components and produce charcoal. After cooling, the charcoal is graded based on size and quality and then packaged for various applications, including grilling, cooking, and activated carbon production.

#### **Pista Shell Charcoal:**

To create pista shell charcoal, start by collecting pista shells from sources like the pistachio processing industry or pista farms. These shells are cleaned and prepared by removing any remaining pistachio nut residues and foreign materials. Like coconut and lemon wood, pista shells must be dried to reduce moisture content, which is critical for effective carbonization. The carbonization process can be carried out in kilns or retorts, similar to other biomass materials. After carbonization, the charcoal is allowed to cool and is then graded based on size and quality. The final step involves packaging the pista shell charcoal for distribution and use in various applications, such as grilling, cooking, and environmental initiatives.

#### **Lemon Wood Charcoal:**

Lemon wood charcoal production begins with the selection of mature lemon wood from lemon trees or similar sources. The wood is then cut into manageable pieces or chips, followed by a drying process to reduce moisture content. Carbonization, often conducted in kilns or retorts, involves heating the dried wood chips in the absence of oxygen. This process drives off volatile components, leaving behind charcoal. Cooling the charcoal is essential to prevent combustion, after which it is graded based on size and quality. The final step involves packaging the lemon wood charcoal for distribution and sale, with different grades serving different purposes, including grilling and cooking.

Each of these preparation processes requires careful attention to detail to ensure the quality and suitability of the resulting charcoal for its intended purpose. The choice of equipment and techniques may vary depending on factors such as scale of production and specific product requirements, but the fundamental steps of harvesting or sourcing, drying, carbonization, cooling, grading, and packaging are common to all three materials. Additionally, environmental considerations and sustainable practices are essential aspects of these processes to minimize their ecological impact.

#### **Analyzing the Total carbon content (TOC)**

The purpose of analyzing the total carbon content from lemon wood, coconut shells, and pista shells is to determine the amount of carbonaceous

material present in these biomass sources. This analysis serves several important purposes:

**Fuel Quality Assessment:** Understanding the total carbon content is crucial for assessing the suitability of these materials for use as fuel sources. Charcoal, which is produced from these materials, is widely used for cooking, heating, and industrial processes. A higher carbon content indicates a better-quality fuel that can produce more heat and burn efficiently.

**Carbon Sequestration Potential:** Analyzing the carbon content helps estimate the carbon sequestration potential of these biomass sources. When converted into charcoal and added to the soil as biochar, the carbon remains sequestered, contributing to carbon capture efforts and helping mitigate climate change.

**Environmental Impact Assessment:** Knowing the carbon content is essential for evaluating the environmental impact of charcoal production from these materials. Charcoal production can release carbon dioxide (CO<sub>2</sub>) into the atmosphere, and understanding the carbon content helps estimate the net carbon emissions or sequestration associated with this process.

**Product Quality Control:** In industrial and commercial applications, the total carbon content is critical for quality control. It ensures that the resulting charcoal meets the desired specifications for specific applications, such as grilling, metallurgy, or activated carbon production.

**Resource Management:** Analyzing the total carbon content can aid in sustainable resource management. It helps assess the potential of these biomass sources as raw materials for charcoal production, promoting efficient use of natural resources.

**Comparative Analysis:** Comparing the carbon content of different biomass sources like lemon wood, coconut shells, and pista shells allows for the selection of the most suitable raw material for specific applications based on their carbon content and properties.

**Research and Development:** Researchers and scientists may use total carbon content data to develop improved methods for biomass conversion into charcoal, explore new applications, and optimize production processes.

In summary, analyzing the total carbon content from lemon wood, coconut shells, and pista shells serves multiple purposes, ranging from

assessing their fuel quality and environmental impact to promoting sustainable resource management and guiding research and development efforts. This data is essential for making informed decisions regarding the utilization of these biomass sources in various industrial, environmental, and energy-related applications.

#### **Method Of (Toc) Total Organic Carbon Test:**

The determination of Total Organic Carbon (TOC) is a crucial analytical procedure employed in various scientific fields, including environmental science, water quality assessment, and the characterization of organic matter in samples. One commonly used method for TOC analysis is the High-Temperature Combustion Method. This method relies on the combustion of organic carbon within a sample to generate carbon dioxide (CO<sub>2</sub>), which is then quantified to determine the TOC content. The method typically involves the use of specialized equipment known as a TOC analyzer, which consists of key components such as a sample injection system, a high-temperature combustion furnace, a catalytic converter, and a detector. Calibration of the TOC analyzer with standard solutions of known TOC concentrations is an essential initial step to ensure accurate measurements.

Once calibrated, the sample, which may be liquid, is prepared accordingly, often involving processes like filtration or acidification to eliminate inorganic carbon and ensure the organic carbon is in a suitable form for analysis. The prepared sample is then injected into the TOC analyzer, where it undergoes high-temperature combustion within the furnace, typically at temperatures ranging from 680 to 750°C. During combustion, the organic carbon within the sample is oxidized into CO<sub>2</sub>. The resulting CO<sub>2</sub>, along with a carrier gas (usually oxygen or helium), is transported to a detector within the analyzer. Various detection techniques, such as non-dispersive infrared (NDIR) spectroscopy or chemiluminescence, are employed to quantify the concentration of CO<sub>2</sub>. Utilizing the calibration curve generated earlier, the TOC analyzer calculates the TOC concentration in the sample. This concentration is reported in units such as milligrams of carbon per liter (mg/L) or parts per million (ppm). Routine quality control measures are crucial in TOC analysis and include regular calibration checks with standards of known TOC concentrations, method blanks to monitor potential contamination, and the analysis of duplicate samples to ensure the precision and accuracy of the TOC analyzer. It is important to note that alternative TOC analysis methods exist, each with

its own set of advantages and applications, and the choice of method may depend on specific analytical requirements and available equipment. Regardless of the method used, adherence to manufacturer instructions and relevant regulations is essential for reliable TOC analysis.

**Analyzing the Total Organic Carbon (TOC) Content for Coconut, Pista, and Lemon Wood Charcoal Analyses**

Charcoal, a carbon-rich material produced through pyrolysis, finds diverse applications in industries such as grilling, water purification, and agriculture. The total organic carbon (TOC) content in charcoal samples derived from different sources, like coconut shells, pista shells, and lemon wood, holds significant importance in assessing their suitability for various applications and understanding their environmental impact. This study aims to investigate and compare the TOC content in charcoals from these distinct natural sources through the following steps

**Sample Collection:** Collect representative charcoal samples from coconut shells, pista shells, and lemon wood. Ensure that the samples are properly prepared to remove any contaminants or inorganic materials.

**Sample Preparation:** Grind the charcoal samples into a fine, homogenous powder to ensure uniformity and facilitate accurate analysis.

**TOC Analysis:** Employ a reliable TOC analysis method, such as the High-Temperature Combustion Method, to measure the TOC content in the charcoal samples. This involves combusting the organic carbon in the samples to generate CO<sub>2</sub>, which is then quantified.

**Quality Control:** Include method blanks and duplicate samples to monitor potential contamination and assess the precision of the TOC analysis.

**Data Analysis:** Calculate the TOC content in each charcoal sample based on the concentration of CO<sub>2</sub> generated during combustion. **Express the results in units like mg of carbon per gram of charcoal.**

**Comparative Analysis:** Compare the TOC content among the different charcoal samples to identify variations and trends. Assess whether the source material (coconut, pista, or lemon wood) significantly impacts TOC content.

**TOC-Total organic carbon test:**

The following report presents the results of the organic carbon content analysis conducted on three charcoal samples. The analysis aims to determine the percentage of organic carbon present in each sample. The organic carbon content for each sample is presented in the table below

Sample	Parameter	Test method	Unit	Result
CS	Organic carbon content	Inhouse method	%	72.30%
PS				71.84%
LW				64.69%

Namely ,CS-Coconut Charcoal PS-Pista shell charcoal, LW-Lemon wood charcoal  
Based on the analysis conducted, the organic carbon content of the three charcoal samples was determined.

**Applications and Implications:**

**Suitability for Cooking:** Evaluate the TOC content's influence on the efficiency and performance of charcoal as a cooking fuel. Charcoal with higher TOC content may burn hotter and longer, making it ideal for grilling and cooking.

**Carbon Sequestration Potential:** Assess the carbon sequestration potential of these charcoals when incorporated into soil as biochar. Determine which source material has the most significant impact on soil carbon sequestration.

**Environmental Considerations:** Investigate the environmental implications of TOC content variations in charcoals, including potential differences in greenhouse gas emissions during production and soil carbon enhancement.

**Sustainable Sourcing:** Consider the findings when selecting source materials for

charcoal production, promoting sustainable practices and resource management.

## II. CONCLUSION :

In conclusion, the analysis of total carbon content in natural wood and shell charcoal samples provides valuable insights into the quality and suitability of these materials for a wide range of applications. The identification of total carbon content is a critical parameter in assessing their performance and environmental impact. Here are some key points summarizing the findings and uses of natural wood and shell charcoal based on their Quality Assessment, Energy Source, Environmental Impact, Carbon Sequestration: Agriculture, Water Purification. The analysis of total carbon content in natural wood and shell charcoals provides critical data that influences their suitability for various applications, ranging from energy production to environmental stewardship. These charcoals, with their unique properties, play a vital role in addressing energy needs, enhancing agricultural practices, and contributing to environmental sustainability through carbon sequestration and water purification. Therefore, the identification of total carbon content is fundamental in optimizing their use and ensuring their positive impact on both human well-being and the environment.

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