Physical Quality of Ultrasonicated Liquid Smoke as the Goat Meat Coating

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Abstract. Liquid smoke is an alternative material to replace conventional smoking methods. This study aims to see the physical quality of liquid smoke from wood and leaves of Kusambi and liquid smoke from coconut shells after being given ultrasonic treatment at pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS), Oxidation-Reduction Potentials (ORP), Specific Gravity (SG), Colors, and Salinity. This research is a laboratory experiment using Randomized Block Design (RBD) with two types of liquid smoke and five groups of various concentrations of liquid smoke and was carried out for three repetitions. Control treatment using pure aquadest without any mixture with ultrasonic treatment. There are two types of liquid smoke solutions, Kusambi liquid smoke and coconut shell liquid smoke, each of which is grouped into five groups, namely liquid smoke solutions with concentrations of 0%, 1%, 2%, 3%, and 5%. Each sample was treated with an ultrasonic bath at room temperature for 10 min. Data were analyzed using Analysis of Variance (ANOVA). If the data showed a significant difference, it is continued with Duncan Multiple Range Test (DMRT). The average value of pH is 3.91–4.37. Liquid Smoke has acidic compounds, such as acetic acid, propionic acid, butyric acid, and valeric acid, which can affect the pH level of each increase in concentration. The average value of EC is 60.27–237.47 S/cm, the average value of TDS is 30.73–115.73 ppm, the average value of lightness (L*) 23.35–23.50%, the average value of redness (*a) is −4.54%–−3.85%, the average value of yellowness (*b) is 3.34–4.01%, the average value of ORP is 298.07 – 317.73 mv. The SG value for all samples is 1.002, and the average salinity value is 25.73–119.80 ppm. The difference in the concentration of liquid smoke did not have a significant effect ($P > 0,05$) on the EC, TDS, Color, and SG tests. The difference in the concentration of liquid smoke had a very significant effect ($P < 0,01$) on the pH test and also gave a significant effect ($P < 0,05$) on the ORP test and Salinity Test. The different kinds of liquid smoke did not have a significant effect ($P > 0,05$) on the Color L* and SG test. However, the different kinds of liquid smoke had a significant effect ($P < 0,05$) on the pH test, EC test, TDS test, Colors a* and b* test, ORP test, and salinity test. In conclusion, the liquid smoke solution from Kusambi wood is better than the coconut shell liquid smoke in terms of pH, EC, TDS, ORP, and Salinity values.

Keywords: liquid smoke · ultrasonic · physical quality

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1 Introduction

Consumption of meat in Indonesia is slowly increasing every year. Processing meat consider to increase the flavor of the meat and can extend the shelf life [1]. One of the oldest methods for preserving meat and its preparations is smoking. The smoking method is a combination of the drying, salting, and smoking food preservation techniques [2]. Generally, people employ traditional methods to smoke meat, particularly the practice of smoking meat in a smokehouse, where the smoke is derived directly from the burning of hardwoods such as kusambi, acacia, and coconut shells [3], and the goal of the smoking procedure is to increase the shelf life of the product [2]. However, in its evolution, particularly today, the goal is to acquire a specific appearance and smoked flavor in food items [2].

This conventional approach inhibits the absorption of cancer-causing benzo[a]pyrene chemicals, upon closer investigation. Benzo(a)pyrene is a marker for the existence of Polycyclic aromatic hydrocarbons (PAH), which are hazardous to human health [4]. Regarding PAHs, the greatest class of chemical carcinogens is known to be involved in cancer-causing agents in humans, and long-term exposure to PAHs can be lethal. Despite the fact that the original intent of smoking was beneficial, it turns out that smoking produces substances that are harmful to health [2]. Several cancer-causing chemicals, including as benzo(a)pyrene, are present in smoked products [2]. To enhance the quality of processed, smoked meat, liquid smoke has been produced.

Using liquid smoke for fumigation can lead in a uniform product [2]. The final flavour is also homogeneous, and its density and scent may be adjusted [2]. It is more environmentally beneficial since it conserves wood, lowers pollution, and prevents tar compound accumulation. The sort of wood used as a source of smoke should be derived from hardwood species in order to provide the desired high-quality smoke [5]. Kusambi wood or kesambi (*Schleichera oleosa*) is commonly used in the NTT region, particularly on the island of Timor, to produce their distinctive cuisine, primarily smoked processed beef known as Se'i. Therefore, it is intriguing when viewed in a new form, namely liquid smoke from Kusambi wood. In addition to Kusambi wood's liquid smoke, coconut shell is a low-moisture hardwood. Calculated from the dry weight, the water content ranges from 6–9%t and is composed of cellulose, hemicellulose, and lignin [6]. That coconut shells are composed of hemicellulose, cellulose, and lignin. Therefore, after undergoing pyrolysis, all of these components will provide scent and preserve the smoking product. Utilizing coconut shells to create liquid smoke is another way to reduce coconut shell waste and boost its utility and resale value.

Liquid smoke as a dissolved material still necessitates a more sophisticated extraction technique so that the solvent and liquid smoke as the dissolved material can combine flawlessly, resulting in a liquid smoke solution with even greater properties. Ultrasonic waves are sound waves whose frequency is more than 20 kHz. Ultrasonic-assisted extraction methods can be used to produce a larger antioxidant content in a shorter amount of time, and because this technique is non-destructive and non-invasive, it can be applied to a variety of media [7]. The ultrasonic extraction method can process the extraction of organic compounds with organic solvents in such a way that the cell walls of the material are broken down by ultrasonic vibrations, allowing the content to be extracted more rapidly [8]. When ultrasonic waves travel through a medium, the medium will experience vibrations. The medium employed for propagation is liquid. This process is referred to as ultrasonic bath extraction. The frequency of ultrasonic waves will produce vigorous agitation and promote osmosis between the solvent and the dissolved substance, thereby accelerating the extraction process.

This research was done to learn more about the physical properties of liquid smoke derived from two distinct sources, namely Kusambi wood and coconut shell, after ultrasonic treatment. This study intends to determine whether there are changes in the pH, EC, TDS, ORP, and salinity values of the two types of liquid smoke when subjected to ultrasonic treatment with various liquid smoke concentrations.

2 Research Methods

2.1 Materials and Tools

This study utilized 100 ml of liquid smoke from Kusambi wood and 100 ml of liquid smoke from coconut shell, 1,000 ml of Aquades, plastic wrap, beaker glass, measuring cup, pipette, tissue, scissors, water quality measurement device C-600, colorimeter CS-10, and ultrasonic cleaner BK-2000.

2.1.1 Research Methods

This research makes use of an experimental laboratory method. The experimental design employed is a randomized block design with two types of liquid smoke and five concentration groups, namely each type of liquid smoke (Kusambi wood and coconut shell) with a liquid smoke solution concentration of 0%, 1%, 2%, 3%, and 5% per 100 ml of distilled water for each sample.

2.1.2 Research Procedure

1. Prepare the necessary materials and equipment.
2. Pour 100 ml of Aquadest into each beaker glass containing 100 ml.
3. Take liquid smoke and measure 1 ml, 2 ml, 3 ml, and 5 ml of it using a measuring cup.
4. Pour each liquid smoke concentration into a beaker glass containing 100 ml of distilled water, so that there are a total of ten samples.
5. Apply an identification label to each beaker glass, and then cover each glass with plastic wrap to prevent exposure to dust and other contaminants.
6. The sample is then treated with ultrasonic vibration for 10 min using an ultrasonic water bath cleaner.
7. The sample is prepared for testing with the C-600 water quality measurement device.

2.1.3 Data Analysis

If the ANOVA (Analysis of Variance) revealed a statistically significant difference in the data, the Duncan Multiple Range Test is performed (DMRT).

3 Results and Discussion

The analysis of variance showed that the difference in concentration of liquid smoke did not give a significant difference ($P > 0.05$) on the EC, TDS, Color, and SG tests. The difference in concentration of liquid smoke has a very significant impact ($P < 0.01$) on the pH test. Also, it has a very significant effect ($P < 0.05$) on the ORP and salinity tests. While the different types of liquid smoke used had no significant effect ($P > 0.05$) on the L* color and the SG test. However, the different types of liquid smoke were significantly affected ($P < 0.05$) on pH, EC, TDS, Color a* and b*, ORP, and salinity tests.

3.1 pH Test

Table 1 shows that the average pH value for coconut shell liquid smoke is more acidic, reaching 3.91 compared to the pH value for wood liquid smoke, which is 4.37. The difference between the two types of liquid smoke was significant ($P < 0.05$). The pH level in liquid smoke is determined by the level of phenol and acidity [9]. The pH level is determined by the water content, the amount of protein and fat contained in the water [10].

The higher the phenol level, the higher the organic acid compounds contained in the liquid smoke, so the pH level is also more acidic. The aroma and color of liquid smoke are also influenced by its phenol content. Phenol is also one of the chemical compounds that play a role in food preservation because it contains antioxidants along with organic and carbonyl acids, which are the result of pyrolysis of cellulose, hemicellulose, and lignin [4]. The chemical content of liquid smoke is influenced by many factors, such as the temperature during pyrolysis., wood species, and wood moisture content [6]. The

Table 1. The average value of pH, EC, TDS, color, SG, ORP, and Salinity test results in two different types of liquid smoke

Parameter	Type of liquid smoke	
	Kusambi Wood	Coconut Shells
pH	$4{,}62 \pm 1{,}23^{b}$	$4{,}18 \pm 1{,}54^{a}$
Electrical Conductivity (µS/cm)	$60{,}27 \pm 32{,}44^{a}$	$237{,}47 \pm 135{,}01^{b}$
Total Dissolved Solids (ppm)	$30{,}73 \pm 17{,}62^{a}$	$115{,}73 \pm 66{,}23^{b}$
Color L*	$23{,}50 \pm 1{,}14$	$23{,}35 \pm 0{,}99$
Color a*	$-4{,}54 \pm 0{,}04^{b}$	$-3{,}85 \pm 0{,}53^{a}$
Color b*	$4{,}01 \pm 0{,}58^{b}$	$3{,}34 \pm 0{,}35^{a}$
Oxidation Reduction Potential (millivolts)	$298{,}07 \pm 18{,}21^{a}$	$317{,}73 \pm 28{,}40^{b}$
Specific Gravity (SG)	$1{,}002 \pm 0$	$1{,}002 \pm 0$
Salinity (%)	$25{,}73 \pm 11{,}21^{a}$	$119{,}80 \pm 66{,}21^{b}$

Note: The same superscribe in the same column gave a significant effect ($P < 0.05$) on the treatment test
a: average redness; b: average yellowness

Table 2. The average value of pH, EC, TDS, color, SG, ORP, and Salinity test results on the concentration of Kusambi liquid smoke

Parameter	**Liquid Smoke from Kusambi Wood Concentration Group**				
	0%	**1%**	**2%**	**3%**	**5%**
pH	6,83	4,12	4,09	4,06	4,02
Electrical Conductivity (μS/cm)	11,67	54	65,67	68,3	101,67
Total Dissolved Solids (ppm)	5,67	26	33	34	54
Color L*	23,78	24	24,04	21,47	24,21
Color a*	-4,51333	-4,54667	-4,55667	-4,49667	-4,61
Color b*	3,42	4,013333	3,73	3,936667	4,97
Oxidation Reduction Potential (millivolts)	267,00	301,3333	302,00	305	315,00
Specific Gravity (SG)	1,002	1,002	1,002	1,002	1,002
Salinity (%)	9,00	22,66667	27,67	29,66667	39,67

Table 3. The average value of the test results of pH, EC, TDS, color, SG, ORP, and salinity on the concentration of coconut shell liquid smoke

Parameter	**Coconut Shell Liquid Smoke Concentration Group**				
	0%	**1%**	**2%**	**3%**	**5%**
pH	6,8	3,57	3,54	3,44	3,40
Electrical Conductivity (μS/cm)	11,67	238	261,33	315	361,33
Total Dissolved Solids (ppm)	5,67	116,66	125,67	151	179,67
Color L*	23,78	23,99	21,85	22,87	24,26
Color a*	-4,51333	-4,26333	-3,49333	-3,24	-3,75
Color b*	3,42	3,446667	3,28	2,81	3,76
Oxidation Reduction Potential (millivolts)	267,00	330,6667	329,33	329	332,67
Specific Gravity (SG)	1,002	1,002	1,002	1,002	1,002
Salinity (%)	9,00	122,6667	130,00	155	182,33

pyrolysis results of cellulose, hemicellulose, and lignin compounds will produce organic acids, phenols, and carbonyls with different portions depending on the type of wood, wood moisture content, and the pyrolysis temperature used [11]. The phenol content of liquid smoke from coconut shells is 14.96%, while the phenol content of liquid smoke of Kusambi wood is 15.95% and 14.19% at 400 °C and 450 °C, respectively [6].

Table 4. Chemical Content of Coconut Shell [7]

Komponen	Presentase (%)
Cellulose	33,61
Hemicellulose	19,27
Lignin	36,51

This pH value also directly indicates the quality of the liquid smoke. High-quality liquid smoke has a low pH value because it shows wood components' decomposition level in producing high organic acids. The high level of organic acids in liquid smoke will affect the shelf life of smoked products and their organoleptic properties. The coconut shell belongs to the hardwood group because it is composed of lignin 36.51%, cellulose 33.61%, and hemicellulose 29.27% [3]. The chemical substances produced from burning wood are 25% hemicellulose, 50% cellulose, and 25% lignin [5] (Table 4).

The difference in the concentration of liquid smoke used between the two types has a significant effect ($P < 0.01$). Tables 2 and 3 show that each increase in the concentration of liquid smoke always reduces the pH level, making the solution more acidic. It happens because the more significant the concentration of liquid smoke is, the greater the chemical content of liquid smoke. Liquid smoke is acetic acid produced through a pyrolysis process consisting of cellulose, hemicellulose, and lignin components [12]. Sahrum, Syaiful and Al-Ghazali [13] stated that liquid smoke is a form of pyrolysis of compounds such as phenol groups, carbonyl, and acid groups, all of which have functions as antioxidants, antimicrobials and also have role in providing specific flavors and aromas.

3.2 Electrical Conductivity Test

Table 1 shows that the average level of Electrical Conductivity (EC) in the coconut shell liquid smoke solution is higher, reaching 237.47 S/cm, while the liquid smoke solution from Kusambi wood only reaches 60.27 S/cm. The difference between the two types of liquid smoke was significant ($P < 0.05$). EC is often used to test the quality of a solution. EC is used to measure the capacity of a liquid to conduct electric current. The level of electrical conductivity of a solution will be proportional to the level of dissolved salt content in a solution [14]. The higher the salt content of a solution, the higher the level of electrical conductivity. It directly illustrates that the liquid smoke solution from coconut shells has high salt content, so it gets a high value in the electrical conductivity test.

Tables 2 and 3 also show that the difference in concentration of liquid smoke does not provide a significant difference ($P > 0.05$) in the electrical conductivity level. It is because the ultrasonic waves managed to break down the dissolved compounds, namely liquid smoke, to be more mixed with the solvent, namely distilled water. Thus, increasing the concentration of liquid smoke does not significantly increase the number of electrical conductivity tests, although there is still an increase. Using ultrasonic waves, the extraction process of organic compounds will be faster and homogeneous with the solvent because the cell walls of the dissolved material will break so that the content in it will be mixed with the solvent [7].

3.3 Total Dissolved Solids

Table 1 shows that the average TDS level in the coconut shell liquid smoke solution is higher, reaching 115.73 ppm, while the liquid smoke solution from Kusambi wood only reaches 30.73 ppm. The results obtained between the two types of liquid smoke are significant ($P < 0.05$). TDS measures the concentration of dissolved ions. The value of TDS is usually in a straight line with the value of EC. EC is a measure of the capacity of a liquid to conduct an electric charge whose ability depends on the concentration of dissolved ions, the strength of the ions, and the measurement temperature [15]. The TDS concentration describes the presence of inorganic salts and small amounts of organic matter in water. The standard TDS concentration that can still be tolerated for health is between 500 mg/L and 1,000 mg/L [16]. Water can also be grouped according to its TDS concentration classification. Type I, namely fresh water with TDS <1,000 mg/L; type II is brackish water with a TDS between 1,000–10,000 mg/L; type III is salt water with a TDS of 10,000–100,000; type IV is salt water >100,000 mg/L [17]. In the liquid smoke solution from coconut shells, the high levels of TDS are also due to the high level of EC. This indicates a high level of concentration of ions dissolved in it. However, the TDS level is still at a safe level for consumption. According to the standard criteria for bottled drinking water, it has been regulated by SNI 01-3553-2015 (Table 5).

Table 5. Standard Criteria for Testing Packaged Drinking Water SNI 01-3553-2015

No.	Name of Test	Standard	Unit
1.	Ozon	0,05–0,25	Mg/l
2.	Total Dissolve Solids (TDS)	Max. 500	Mg/l
3.	pH	6,0–8,5	

If it is converted to Mg/l, the coconut shell liquid smoke solution has a TDS level of 115.73 ppm or 115 Mg/l, while the liquid smoke solution from kusambi wood only reaches 30.73 ppm or 30.7 Mg/l, so it is still far from the limit. Safe, namely a maximum of 500 mg/l.

Tables 2 and 3 also show that the difference in concentration of liquid smoke does not significantly affect the TDS value ($P > 0.05$). It is similar to the results of the EC test. Namely, the treatment of ultrasonic waves can reduce solute particles so that they are extracted more entirely and do not leave ion deposits that can cause a significant increase in the TDS value. The extraction process, with the help of ultrasonic waves, can damage cell wall permeability and increase cell damage. It causes the solute to become more homogeneous with the solute [18].

3.4 Color Test

3.4.1 Color L*

Table 1 shows that the average L* color in the type of liquid smoke solution from Kusambi wood is higher, reaching 23.50%. In comparison, the liquid smoke solution from coconut shells is not much different or even close to 23.35% for the brightness level. The results obtained between the two types of liquid smoke were insignificant ($P > 0.05$). The higher the L (Lightning) value, the brighter the sample will be [12]. After the distillation process, liquid smoke will change color, which was previously dark in color, to become more faded and lighter because of the tar content separated from other compounds with low boiling points [8]. Tar is a toxic compound for the body, so it must be filtered through the distillation method to lose its tar content. The liquid smoke used is the third distillation and is also a grade 1 liquid smoke specifically for food. So that the physical characteristics of grade 1 liquid smoke are clear and yellowish, both liquid smoke from Kusambi wood and coconut shell liquid smoke have approximately the same color brightness level because they have both gone through the third distillation stage. Hence, the tar content, which is dark black, is minimal.

As for the difference in concentration, there is also no significant effect ($P > 0.05$) for the L* color value. Because in addition to liquid smoke, liquid smoke grade 1 is already food grade, the concentration used in making the liquid smoke solution is minimal, only 1–5%, and mixed into 100 ml of pure aquadest. So, there is no significant L* color or brightness effect.

3.4.2 Color a*

Table 1 shows that the average color of a* in the type of liquid smoke solution from coconut shell is higher -3.85% than the liquid smoke of Kusambi wood is lower, reaching -4.54% for the color content of a*. The differences between the two types of liquid smoke were significant ($P < 0.05$). The higher the a* value, the reddish the sample color [13]. Liquid smoke from the pyrolysis results will produce a reddish-brown color in the initial results, and this is due to the content of tar compounds which are black and specific gravity heavier than water [12]. When the purification process is carried out with the repeated distillation method, the reddish-brown color will change to orange, yellow, and then transparent yellowish. The Kusambi liquid smoke sample still looks a little brown even though it is clear compared to coconut shell liquid smoke. However, if it is mixed in distilled water, the color will look the same between the sample solution and the liquid smoke of Kusambi and coconut shell liquid smoke.

Tables 2 and 3 show that there is no significant a* color difference for the difference in the concentration of liquid smoke used.

3.4.3 Color b*

Table 1 shows that the average color of b* in the type of liquid smoke solution of Kusambi wood is higher, reaching 4.01%, while the liquid smoke solution from coconut shell is 3.34% for the level of color b*. The differences between the two types of liquid smoke were significant ($P < 0.05$). The higher the b* value, the more yellow the sample will be [12]. The results of the third distillation of liquid smoke from Kusambi wood with liquid smoke from coconut shells are visible in physical appearance. In terms of aroma, the liquid smoke of Kusambi wood is slightly more pungent, and the color is slightly more yellowish than the liquid smoke of coconut shells. The pyrolysis results of cellulose, hemicellulose, and lignin compounds would produce organic acids, phenols, and carbonyls with different portions depending on the type of wood, wood moisture content, and the pyrolysis temperature used [11]. The phenol content of liquid smoke from coconut shells is 14.96% [4], while the phenol content of liquid smoke of Kusambi wood is 15.95% and 14.19% at 400 °C and 450 °C, respectively [6]. Phenol is a compound that functions as an antioxidant and has a role as a taster or flavor in food ingredients [19].

Tables 2 and 3 show that the difference in concentration of each type of liquid smoke does not have a significant effect ($P > 0.05$) for all colors (L*, a*, and b*). This is because the dissolved concentration is minimal, and the distance between concentrations is only a 1–2% difference. So the difference in the color of the solution is not significantly different.

3.5 Oxidation Reduction Potential

Table 1 shows that the average ORP value for coconut shell liquid smoke solution is higher, reaching 317.73 mV, while the liquid smoke solution from Kusambi wood is 298.07 mV. The differences between the two types of liquid smoke were significant ($P < 0.05$). The ORP test shows the ability of water to oxidize its contaminants [20]. ORP is a method to determine the level of a liquid's ability to kill bacteria in water. The higher the ORP value, the shorter the presence of bacteria in the liquid. Both liquid smoke from coconut shells and liquid smoke from Kusambi wood have a reasonably high phenol content. Phenol is also one of the chemical compounds that play a role in food preservation because it contains antioxidants and organic and carbonyl acids resulting from the pyrolysis of cellulose, hemicellulose, and lignin [4]. The phenol content of liquid smoke from coconut shells is 14.96% [4], while the phenol content of liquid smoke of Kusambi wood is 15.95% and 14.19% at 400 °C and 450 °C, respectively [5]. This high phenol content is one of the factors causing the high ability of the liquid smoke solution to kill bacteria in it.

Tables 2 and 3 show that the difference in concentration of the two types of liquid smoke also had a significant effect ($P < 0.05$) on the ORP test value. That the higher the concentration of ORP in the water, the shorter the time needed to kill the bacteria [21]. As the concentration of liquid smoke increases, from 1%-5%, the ORP test value also increases.

3.6 Specific Gravity

Tables 1, 2, and 3 show that the average SG value in all samples is of the same magnitude, namely 1.002 for the type of solution and the difference in concentration levels in coconut shell liquid smoke and Kusambi wood. The differences between the two types of liquid smoke were insignificant ($P > 0.05$). This density is a density ratio with no quantity dimension. It is often represented as the density of a substance medium divided by the density of water with similar external conditions [22]. The distillation and filtration process in the manufacture of food-grade grade 1 liquid smoke makes the characteristics of liquid smoke, especially in its density, the same as water. The addition of ultrasonic treatment also did not significantly affect the specific gravity of all sample solutions.

This method is non-destructive and non-invasive, so it does not damage the chemical structure in the solution [7].

3.7 Salinity

Table 1 shows that the average salinity value of the coconut shell liquid smoke solution is higher, reaching 119.8%, while the liquid smoke solution from Kusambi wood only reaches 25.73%. The differences between the two types of liquid smoke were significant ($P < 0.05$). Salinity is a term used to describe the condition when dissolved salts accumulate in a solution (soil or water) [23]. In this study, coconut shell liquid smoke samples had a high dissolved salt content. It is also supported by the previous test results, EC, and TDS. EC and TDS can also be supporting data for salinity level parameters. Table 1 shows that the average levels of Electrical Conductivity (EC) and Total Dissolved Solid (TDS) in coconut shell liquid smoke are always the highest, reaching 237.47 S/cm and 115.73 ppm.

Tables 2 and 3 show that the difference in concentration of the two types of liquid smoke also had a significant effect ($P < 0.05$) on the salinity test value. Salinity levels will increase if the content of cadmium, metal, soluble chloride, sulfate, and bicarbonate ions increases [23]. Coconut shells contain calcium carbonate salts, which are easily dissolved when water exposure [24].

4 Conclusion

The difference in the liquid smoke solution concentration in ultrasonic has no effect on the EC, TDS, Color, and SG tests. However, the difference in concentration of the liquid smoke solution in ultrasonic has a significant impact on the pH test and affects the ORP and salinity tests. Meanwhile, the difference in the type of liquid smoke used in the ultrasonic does not significantly affect the L* color and the SG test. However, different types of liquid smoke significantly affect pH, EC, TDS, Color a* and b*, ORP, and salinity tests.

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