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The Effect of Burning on the Polycyclic Aromatic Hydrocarbons (PAH) Content in Goat Satay in the East Java Region

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Authors' contributions

This work was carried out in collaboration among all authors. Author GA designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Authors DR, PPR, LER, CNY and ES managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

This study aims to determine the levels of PAHs in commercial goat satay in all cities throughout East Java. PAHs are organic compounds that have two or more benzene rings joined together and are made only of carbon and hydrogen. PAHs can enter the human body through breathing, absorption, or skin contact. PAHs have been shown to have the potential to cause various carcinogenic, mutagenic, and immune disrupting effects. The samples taken for the study were 27 samples. This research was conducted in a non-experimental manner by observing the object of research directly. Data collection techniques in this study were conducted by interview, observation, and chemical analysis in the laboratory. The results showed that the weight of goat satay had an

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average of 119.3 g, the highest burning time of samples with the code MJT-B and MDN-C for 10 minutes 17 seconds, and the distance between charcoal and the highest goat satay meat was in samples with the code PRB-A, PRB-B, BT-A, MJT-A, MJT-B, MDN-A, and MDN-C as far as 1.0 cm, and the highest fat content test obtained from the MDN-C sample code was 0.97 grams. Analysis of PAH compounds was carried out using the chromatographic method. The PAH test obtained the highest results with the sample code MDN-C with the results of Pyrene (Pyr) 0.71 ± 394.87, Fluoranthene (Flt) 0.45 ± 351.21, Anthracene (Ants) 4.41 ± 225.48, and Fluorene (Flr) 0.28 ± 52.60. The results of compounds that have values <0.0004 are declared as samples that do not indicate PAH compounds.

Keywords: Carcinogenic; combustion; fat; goat satay; polycyclic aromatic hydrocarbons.

1. INTRODUCTION

Meat is one of the foodstuffs that is a source of animal protein that is needed by humans. Goat meat has essential amino acids and important nutrients such as iron, zinc, and vitamin B complex and contains a number of micro nutrients such as selenium, phosphorus, and vitamin B12 [1]. Meat can be processed into various types of food, one of which is the favourite of the Indonesian people, namely satay. Satay is a food made from meat that is cut into small pieces then skewered with a stick and then grilled using charcoal.

Satay is processed by burning so that the fat that drips during the combustion process causes the formation of PAH (Polycyclic Aromatic Hydrocarbons). PAH is a carbon ring with a chemical structure in the form of a benzene ring which can be 2 bonds or even 5 series of ring bonds. The more the number of benzene rings, the more harmful it will be to health [2]. There are several PAH compounds, namely Acenaphthylene (Acp), Indeno(1.2.3-cd)pyrene (IcP), Benzo(g.h.l)perylene (BgP), Dibenzo(a.h)anthracene (DhA), Benzo(a)pyrene (BaP), Chrysene (Chr), Benzo(k)fluoranthene (BkF), Benzo(b)fluoranthene (BbF), Benzo(a)anthracene (BaA), Pyrene (Pyr), Fluoranthene (Flt), Anthracene (Ants), Phenanthrene (Phe), Fluorene (Flr), Acenapthene (Acp), and Naphthalene (Nap) [3]. The European Commission Scientific Committee on Food (SCF) is of the opinion that PAHs as human carcinogens detected in food are BaP [4].

Indonesians prefer to grill the satay using charcoal. This is believed to enhance the aroma and will affect the texture and flavour of the satay. The use of charcoal as fuel can lead to an increase in BaP content in satay compared to gas grilling. The BaP in goat satay is also influenced by the type of fuel used. This occurs due to the pyrolysis of wood, which contains PAHs, resulting in an increase in BaP content. PAHs tend to form on or near the surface of meat rather than inside it. Research needs to be conducted to identify PAH carcinogens contained in commercial goat satay.

2. MATERIALS AND METHODS

2.1 Sampling

Sampling at the location of commercial satay stalls in all cities in East Java. The locations of commercial goat satay sampling cities include Malang City (-7.9786372,112.5493811,12), Blitar City (-8.0947337,112.091434,13), Kediri City (-7.842244,111.9337849,12), Batu City (-7.8806557,112.5017044,14), Madiun City (-7.6299749,111.4868514,13), Mojokerto City (-7.471446,112.4186313,14), Pasuruan City (-7.6513922,112.8844951,14), Probolinggo City (-7.7721163,113.0538167,12), and Surabaya City (-7.2754417,112.630281,12). Each city was sampled in 3 locations so that overall the total samples taken were 27 samples.

2.2 Data Collection

This research was conducted non-experimentally by observing the research object directly using data collection methods by observing directly. Data collection techniques in this study were conducted by interview, observation, and chemical analysis in the laboratory. Data collected were satay weight, meat dimensions, peanut seasoning, shallot slices, burning temperature, burning time, burning distance, fat content, and PAH compound analysis.

2.3 Sample Preparation

Satay samples from various commercial goat satay stalls purchased directly from goat satay stalls in all cities throughout East Java were weighed and the complementary components of the satay were identified. Then the goat satay samples were pureed using a blender until homogeneous. After that, it was packaged with aluminum foil plastic clips to minimize oxidation and dehydration. The packaged samples were placed in a freezer at -200 C.

2.4 Fat Content Test

The research material was commercial goat satay in all cities in East Java. The materials used include petroleum ether, anhydrous sodium sulfate, silica gel, quality alumina (E. Brand USA), helium gas, hydrogen, equadest, n-hexane and dichloromethane solvents.

Weigh 5 g of meat, then put it in an oven at 105°C for 24 hours. The fat flask to be used was dried in an oven at 105°C for 1 hour. The fat flask was cooled in a desiccator for 15 minutes. Samples that have been in the oven as much as ± 2 grams are mashed then weighed and wrapped using filter paper formed into a sleeve. Assemble the extraction equipment from heating mantle, fat flask, soxhlet to condenser. The sample is then put into the soxhlet which is then added with sufficient petroleum ether solvent for 1½ cycles. Extraction was carried out for 4 hours until the solvent fell back through the siphon into the clear fat flask. The fat that has been separated with hexanes is then heated in an oven at 105°C for 24 hours, then the final weighing is done [5].

$$\text{Fat Content} : \frac{W-W1}{W2} \times 100\%$$

W = Sample wight (g)
W1 = Sample before extraction (g)
W2 = Sample weight after extraction (g)

2.5 PAH Test

Analysis of PAH compounds was carried out using the chromatographic method. The equipment used in this study included measuring cups, rotary evaporator (Buchi), vacuum pump, 1.00 mm sieve, AI.204 analytical balance, model 501 oven, handrefractometer (Kenko), van veen grab stainless, gas chromatography FID detector, digital scales, blender, freezer, spoon, aluminum foil, styrofoam, and blue ice. For the determination of PAHs in the samples goat satay were taken as much as 10 grams. The technique developed for PAH analysis is Gas Chromatography Mass Spectrometry (GC-MS). Samples prepared in vials were loaded into a GC system (Trace GC Ultra, Thermo Scientific, Waltham, MA, USA) equipped with an ISQ monoquadrupole mass spectrometer (Thermo Scientific). PAHs were separated using a Thermo Scientific HP-5MS column (15 m × 0.25 mm × 0.25 μm). The gas carrier (helium) always reaches 1 ml/minute. First set the oven temperature to 50℃ and let it rest for 0.1 minute. Then the temperature was increased to 180℃ at a speed of 20℃/min and maintained for 1 min. Then the temperature was increased to 250℃ at 20℃/min and maintained for 1 min, and finally increased to 300℃ at 20℃/min for 3.5 min. The temperature of the injector and detector is maintained at 280℃. The injection volume was 1 μL and samples were injected separately [6]. The detection limit for the concentration of PAHs in the sample is 0.004 μg/kg, after analysis is complete the results obtained can be collected and validated data PAHs [7].

3. RESULTS

3.1 Weight of Goat Satay And Complementary Components

Samples taken from 27 locations have different weight of goat satay, combustion temperature, combustion time, and burning distance. The weight of the goat satay was obtained using the method of weighing the goat satay using analytical scales. The results obtained showed that the sample with the code SBY-C had the highest weight of goat satay at 177.3 grams, while the lowest result was obtained with the sample code BR-A at 71.3 grams. Weight goat satay above is the weight of goat satay meat in 1 portion or as many as 10 skewers of goat satay.

Combustion time, combustion temperature, and charcoal distance with mutton satay meat from each location are different. Combustion time of goat satay was carried out by direct measurement using the stopwatch time study method, which is a work measurement method using a stopwatch as a time measuring tool. The highest combustion time is in samples with the code MJT-B and MDN-C for 10 minutes 17 seconds, while the lowest burning time is in sample code K-B for 4 minutes 0 seconds. The burning temperature of goat satay was carried out using the thermometry method, which is a work measurement method using a using a thermometer. The highest combustion temperature is in the sample with the code PRB-A of 593.90 C, while the lowest combustion temperature is in the sample code PRB-C of 100.20 C.

Table 1. Weight of goat satay and complementary components

Sample	Satay Weight (g)	Dimensions Meat (cm)	Sauce Weight (g)	Slice Onion (g)	Temperature Combustion (^{0}C)	Time Combustion (m)	Distance Burner (cm)
K-A	87.2	2.2	150.1	18.8	456.7	6.16	3.5
K-B	113.7	2.5	223.2	24.7	407.0	4.00	3.0
K-C	137.0	2.0	123.7	33.0	520.3	5.17	2.0
BR-A	71.3	2.1	170.8	27.4	489.4	6.11	2.0
BR-B	134.6	2.2	193.4	21.7	384,0	6.25	3.0
BR-C	95.4	2.0	230.5	32.8	481.7	4.45	2.0
PSR-A	108.9	2.1	208.9	17.9	340.2	7.14	3.0
PSR-B	126.8	2.2	289.8	23.4	156.6	9.47	3.0
PSR-C	115.1	2.4	125.4	25.2	211.7	6.20	2.0
PRB-A	116.0	2.4	117.8	19.3	593.9	4.28	1.0
PRB-B	76.5	2.6	134.7	21.4	327.3	4.55	1.0
PRB-C	161.2	3.0	167.4	20.8	100.2	6.29	2.0
MLG-A	131.0	2.5	238.7	31.7	357.7	10.04	1.5
MLG-B	114.7	2.4	458.3	150.7	297.9	4.70	2.0
MLG-C	128.6	3.2	215.5	21.9	305.6	8.20	2.0
BT-A	144.1	2.3	304.2	22.3	296.7	7.30	1.0
BT-B	149.4	2.2	276.7	27.9	313.0	6.38	2.0
BT-C	127.7	2.0	213.1	31.4	274.7	8.69	1.5
MJT-A	152.1	2.5	231.3	36.3	266.4	6.10	1.0
MJT-B	126.5	2.3	145.1	18.6	328.1	10.17	1.0
MJT-C	118.7	2.2	185.2	21.2	266.5	5.42	1.5
MDN-A	135.8	2.0	213.6	28.4	320.5	9.09	1.0
MDN-B	91.1	2.3	332.5	23.9	274.2	4.09	1.2
MDN-C	100.0	2.4	282.3	19.8	288.9	10.17	1.0
SBY-A	98.8	2.7	241.6	29.3	276.8	5.36	3.0
SBY-B	82.2	2.0	224.8	21.6	492.5	5.46	1.5
SBY-C	177.3	2.8	190.5	32.6	369.8	7.48	2.0

Table 2. Fat content

Sample	Fat Content (%)
K-A	0.96
K-B	0.90
K-C	0.90
BT-A	0.92
BT-B	0.63
BT-C	0.78
MLG-A	0.90
MLG-B	0.94
MLG-C	0.68
SBY-A	0.91
SBY-B	0.93
SBY-C	0.86
MDN-A	0.87
MDN-B	0.89
MDN-C	0.97
PSR-A	0.91
PSR-B	0.88
PSR-C	0.53
PRB-A	0.77
PRB-B	0.78
PRB-C	0.87
MJT-A	0.86
MJT-B	0.78
MJT-C	0.90
BR-A	0.68
BR-B	0.94
BR-C	0.80

Table 3. PAH test

No	Sample	Unit	Acp	IcP	BgP	DhA	BaP	Chr	BkF	BbF	BaA	Pyr	Flt	Ants	Phe	Flr	Acp	Nap
1.	K-A	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
2.	K-B	µg/kg	0.06±40.90	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.79±217.17	nd	nd	nd	nd	nd
3.	K-C	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
4.	BT-A	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
5.	BT-B	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
6.	BT-C	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
7.	MLG-A	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.99 ±154.43	nd	nd	nd	nd	nd
8.	MLG-B	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.17±139.22	nd	nd	nd	nd	nd
9.	MLG-C	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
10.	SBY-A	µg/kg	nd	nd	0.02 ±1.32	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
11.	SBY-B	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
12.	SBY-C	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.4±179.73	8.24±217.57	0.51±92.46	nd	nd	nd	nd
13.	MDN-A	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5.69±138.75	nd	nd	nd	nd	nd
14.	MDN-B	µg/kg	0.26±9.42	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.02±92.06	nd	nd	nd	nd	nd
15.	MDN-C	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.71±394.87	0.45±351.21	4.41±225.48	nd	0.28±52.60	nd	nd
16.	PSR-A	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	2.84±199.99	1.65±169.60	0.16±41.83	nd	0.89±21.01	nd	nd
17.	PSR-B	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.95±268.31	23.28±212.09	0.42±74.53	nd	0.18±40.55	nd	nd
18.	PSR-C	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.6±223.78	1.82±113.06	nd	0.28±123.82	nd	nd
19.	PRB-A	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	4.19±175.72	0.88±202.71	3.65±77.30	nd	2.35±63.12	nd	nd
20.	PRB-B	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
21.	PRB-C	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
22.	MJT-A	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
23.	MJT-B	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
24.	MJT-C	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	0.25 ±20.42	nd	0.43±97.36	0.46±30.86	nd	0.29±10.65	nd	nd
25.	BR-A	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
26.	BR-B	µg/kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd
27.	BR-C	µg/kg	nd	nd	0.01±1.31	nd	Nd	nd	nd	nd	nd	nd	Nd	nd	nd	nd	nd	nd

The method for measuring the highest distance between charcoal and mutton satay meat using a measuring ruler uses a linear distance measurement method. Linear measurements are used to determine the distance traveled by the satay burning process, which can be an indicator for researchers to evaluate the efficiency of the cooking process or other factors related to satay burning. The highest distance between charcoal and mutton satay meat is in samples with the code PRB-A, PRB-B, BT-A, MJT-A, MJT-B, MDN-A, and MDN-C as far as 1.0 cm, while the lowest distance between charcoal and goat satay meat is found in sample code K-A as far as 3.5 cm.

3.2 Fat Content

After taking goat satay samples from 27 locations and testing the fat content, the highest result was obtained with sample code mdn-c. The highest fat content test result obtained from sample code mdn-c is 0.97%, while the lowest fat content result obtained from sample code bt b is 0.63%.

3.3 PAH Test

The data in the table shows the presence of PAHs analyzed in different samples. The concentration of various PAH compounds was measured in micrograms per kilogram (μg/kg) in each sample. Some of the PAH compounds analyzed included Acp, IcP, BgP, DhA, BaP, Chr, BkF, BbF, BaA, Pyr, Flt, Ants, Phe, Flr, Acp, and Nap [3].

After taking goat satay samples from 27 locations and conducting PAH tests, the highest results were obtained with sample code MDN-C. The compound results obtained from sample code MDN-C are Pyr 0.71 ± 394.87, Flt 0.45 ± 351.21, Ants 4.41 ± 225.48, and Flr 0.28 ± 52.60. These data provide information on the presence and concentration of various PAH compounds in the analyzed samples to assess the potential for environmental contamination and evaluate the risks associated with PAH exposure. Compound results that have values <0.0004 are declared as samples that do not indicate PAH compounds.

4. DISCUSSION

4.1 Weight Of Goat Satay And Complementary Components

The weight of goat meat used in each location varies. The results obtained showed that the sample with the code SBY-C had the highest weight of goat satay at 177.3 grams, while the lowest result was obtained with the sample code BR-A at 71.3 grams. Weight goat satay above is the weight of goat satay meat in 1 portion or as many as 10 skewers of goat satay. The size of the meat and the nature of the meat changes depending on the processing method chosen [8]. Meat is thermally processed mainly to improve and obtain the desired color, flavor, and aroma [9].

The highest combustion temperature is in the sample with the code PRB-A of 593.9^0 C, while the lowest combustion temperature is in the sample code PRB-C of 100.2^0 C. Satay burning is generally done at high temperatures or hot. Temperature is one of the most important factors affecting PAH content in heat-treated meat products [10]. High heat temperatures above 200^0 C can trigger pyrolysis of organic materials including fats to produce non-polar and lipophilic PAHs [11].

PAH levels increase when food is grilled closer to the heat source regardless of the heat source [12]. Factors affecting PAH content in smoked or grilled products include the type of food, meat part, food additives, food fat content, type of fat content, and type of fat content fuel, processing method, length of process, distance and proximity of product to heat source, processing temperature, process flow, cleanliness and maintenance of equipment, design of smoking chamber, type of smoke generator, and equipment used to mix smoke and air [13].

4.2 Fat Content

Fat content is considered an important parameter that contributes to the texture, flavor, mouthfeel, and overall perception of meat. The main drawback of meat products is that they contain high levels of fat and cholesterol but no fiber [14]. , the highest result was obtained with sample code mdn-c. The highest fat content test result obtained from sample code mdn-c is 0.97%, while the lowest fat content result obtained from sample code bt b is 0.63%. The average fat content of raw marinated lean goat satay is 1.50%-2.95% [10]. According to the United States Department of Agriculture, 100 g of goat meat contains 27 g protein, 3 g fat, 143 cal energy and 75 mg cholesterol [15].

Consumption of meat products is the most common intake of PAHs with high fat content more susceptible to PAH contamination [16]. There is a positive relationship between dietary lipid content and PAH levels [17]. Fatty foods are susceptible to PAH contamination due to their dense lipophilic characteristics [18]. Indications of PAH formation are due to melting fat dripping onto hot surfaces and resulting in pyrolysis at high enough temperatures [19].

4.3 PAH Test

PAHs are organic compounds that are generally odorless and colorless. PAHs have two or more benzene rings joined together and are made of only carbon and hydrogen. PAHs have various structures and different levels of toxicity and are categorized based on their structure. UV spectra are very useful in the identification of specific PAHs. Each PAH ring has a unique UV spectrum, resulting in a different absorption spectrum for each isomer. PAHs can enter the human body through breathing, absorption, or skin contact. PAHs have been shown to have the potential to cause various carcinogenic, mutagenic, and immune-disrupting effects. PAHs can disrupt the operation of cell membranes and the enzyme systems connected to those membranes [20].

After taking goat satay samples from 27 locations and conducting PAH tests, the highest results were obtained with sample code MDN-C. The compound results obtained from sample code MDN-C are Pyr 0.71 ± 394.87, Flt 0.45 ± 351.21, Ants 4.41 ± 225.48, and Flr 0.28 ± 52.60. These data provide information on the presence and concentration of various PAH compounds in the analyzed samples to assess the potential for environmental contamination and evaluate the risks associated with PAH exposure. Compound results that have values <0.0004 are declared as samples that do not indicate PAH compounds.

The variety and amount of PAH compounds formed in meat products vary depending on the type of meat, temperature of the heat source used in the combustion process, cooking method, fat content, degree of doneness, oxygen accessibility, distance between the meat and the heat source, and cooking time [18]. In particular, meat products are the most common PAH intake and meat products with high fat content are more susceptible to PAH contamination [16]. There is a positive relationship between dietary lipid content and PAH levels [21]. Fatty foods are susceptible to PAH contamination due to their dense lipophilic characteristics [18].

The highest fat content test result obtained from sample code MDN C is 0.97%. As the surface temperature of the meat and the cooking time increase, droplets of liquid fat on the fire cause a flame to form, resulting in the fat becoming thermally decomposed or pyrolyzed. Consequently, the accelerated formation of PAHs on the surface is considered a possible cause of this increase [22]. The dripping fat causes the flame to flare up, increasing the surface temperature and thus increasing PAH emissions [23]. High fat content will cause more fat to melt, resulting in the release of more PAHs so that the smoke again contaminates the food, and the compounds tend to accumulate on the surface [24].

The results of the study of the highest burning time of the sample with the highest time MDN C for 10 minutes 17 seconds, and the distance between charcoal and the highest mutton satay meat is in the sample with the code MDN C as far as 1.0 cm. PAHs are formed during food processing techniques at high temperatures, such as grilling, smoking, roasting, and frying meat products [25]. Increased PAH concentration obtained during gas or charcoal grilling with varying distances between the meat and the heat source. Grilled foods depend on several processing parameters such as kiln construction, fuel used, temperature, type of meat, and pretreatment of the meat resulting in the final PAH concentration [19]. Grilled meat showed a significant increase in the total amount of 16 PAH compounds for almost all grilled food products with the total risk of PAHs increasing fivefold [26].

5. CONCLUSION

The results showed that the weight of goat satay has an average of 119.3 g, the highest combustion time of samples with code MJT-B and MDN-C for 10 minutes 17 seconds, and the distance of charcoal with the highest goat satay meat is in samples with code PRB-A, PRB-B, BT-A, MJT-A, MJT-B, MDN-A, and MDN-C as far as 1.0 cm. Increased PAH concentration obtained during gas or charcoal grilling with varying distances between the meat and the heat source. The highest fat content test obtained from sample code MDN-C is 0.97%. In particular, meat products are the most common PAH intake and meat products with high fat content are more susceptible to PAH contamination The PAH test obtained the highest results with the MDN-C sample code with the results of Pyr 0.71 ±

394.87, Flt 0.45 ± 351.21, Ants 0.45 ± 351.21, Pyr 0.71 ± 394.87. 4.41 ± 225.48, and Flr 0.28 ± 52.60. Results of compounds that have values <0.0004 are declared as samples that do not indicate PAH compounds. PAHs are formed during food processing techniques at combustion time, the distance of charcoal with the goat satay meat, combustion time, and fat content.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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