PROCEEDINGS OF

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Malang, 18-19 November 2020

“Achieving Resilient and Environmentally Sustainable Animal Industry in the post COVID-19 Pandemic Era”
TABLE OF CONTENT

PREFACE ............................................................................................................................................. i

TABLE OF CONTENT ......................................................................................................................... ii

WELCOME SPEECH ........................................................................................................................... iv

Welcome Message from Rector ........................................................................................................ v

Welcome Message from Dean ........................................................................................................... vi

PROCEEDINGS ................................................................................................................................. 1

The Impact of COVID-19 Pandemic on Poultry Production: Challenges and Prospects
A. Jalaludeen and Stella Cyriac ........................................................................................................... 2

Sustainability of Sheep and Goat Production in Asian Countries  A. K. Thiruvenkadan and J. Muralidharan................................................................................................................................................ 10

Electrical Conductivity of Milk: Measurement and Analysis of Mastitis Detection
Performance on Dairy Cattle T. E. Susilorini, G. Emerald, and Kuswati ........................................... 21

Analysis of Critical Point Amplification of DNA Microsatellite of Capra hircus
D. Wulandari, I. L. Murtika, F. E. Wardani, A. Furqon, W. A. Septian, T. E. Susilorini and S. Suyadi............................................................ 27

Case Study of Critical Point on RFLP (Restriction Fragment Length Polymorphism)
F. E. Wardani, D. Wulandari, I. L. Murtika, A. Furqon, W. A. Septian, T. E. Susilorini, A.
Rachmawati and S. Suyadi ............................................................................................................. 34

Observational Study on Critical Point of Polymerase Chain Reaction (PCR) Process of
Mitochondrial DNA I. L. Murtika, D. Wulandari, F. E. Wardani, A. Furqon, W.A. Septian,
T.E. Susilorini, and S. Suyadi ........................................................................................................ 41

Estimation of Heritability for Body Weight Using Fullsib and Halfsib Method in Etawah
Grade Goat V. M. A. Nurgiartiningsih and C. Safina ......................................................................... 46

5 Ways to Improve Farmer Management Skills of Joper Parent Stock in Berline Farm,
Ngajum, Malang M. H. Natsir, V. M. A. Nurgiartiningsih, O. Sjofjan, W. Firdaus, and Y. F.
Nuningtyas ...................................................................................................................................... 52

The Potential of Antioxidant Activity and the Characteristics of Fingerroot Extract
(Boesenbergia pandurata Roxb. Schlecht.) with Nanoencapsulation Technology N. N. N.
Nida, Z. Zuprizal and B. Ariyadi .................................................................................................. 56

Nutritional Content, Gross Energy and Density of Banana Corn Evaluation from
Nanotechnology and Re-binding as A Hybrid Duck Feeds O. Sjofjan, M. H. Natsir, Y. F.
Nuningtyas,E. A. Putra, and D. N. Adli ...................................................................................... 62

The Effect of Corn Substitution with Re-Binding Banana Hump Flour in Feed on Internal
Organs, Abdominal Fat Percentage and Size of Caeca in Hybrid Ducks O. Sjofjan, M. H.
Natsir, Y. F. Nuningtyas, T. S. Wardani, and D. N. Adli ............................................................. 67

The Effect of Corn Substitution with Palm Kernel Meal with Addition of Enzyme Mananase
in Feed on Carcass Weight, Carcass Percentage, Pieces of Carcass Hybrid Ducks O.
Sjofjan, M. H. Natsir, Y. F. Nuningtyas, F. R. Amalia, and D. N. Adli ...................................... 72
Ruminal Degradation of Selected Local Feeds in Dairy Cattle Using In Sacco Techniques
A. Rosmalia, I.G. Permana, Despal, and R. Zahera ................................................................. 77

The Effect of Fresh Dayak Onion (Eleutherine palmifolia L. Merr) and Storage Time on
Rejected-Duck Nuggets N. Hidayat ............................................................................................ 83

Effect Ozonation on the Physicochemical and Penicillin-G Residues in Dairy Milk D.
Suprapto, L. E. Radiati, C. Mahdi, and H. Evanuarini ............................................................ 91

Extraction of Chicken Head Proteins and Evaluation of Their Functional Properties K. U. Al
Awwaly, I. Thohari, M. W. Apriliyani, and D. Amertaningtyas ................................................ 97

Water Requirements in Hydroponic and Aquaponic Maize Fodder Production Hermanto,
S. Chuzaemi, B. A. Nugroho and I. Subagiyo ....................................................................... 103

The Fermentation Quality of Agricultural Waste-based Complete Feed Silage Treated with
Cellulase and its Effect on Productivity of Kacang Goats B. Santoso, T. W. Widayati, and
B. T. Hariadi ............................................................................................................................. 110

Indonesian Food Culture, Goat Satay: Nutritional Profile and Precursor Compounds of
Heterocyclic Aromatic Amine (HAA) Carcinogens D. Rosyidi, E. Saputro, L. E. Radiati and
W. Warsito ................................................................................................................................... 115
Indonesian Food Culture, Goat Satay: Nutritional Profile and Precursor Compounds of Heterocyclic Aromatic Amine (HAA) Carcinogens

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Abstract

Satay is one of Indonesia's national dishes, the ancestors’ legacy of the Indonesian nation. Every state guest will be treated to a meal in the form of satay. This study was aimed to determine the nutritional profile and precursor compounds of heterocyclic aromatic amine (HAA) carcinogens from goat satay circulating in Kota Batu, East Java, Indonesia. HAA precursor compounds are reducing sugars, amino acids and creatinine in goat meat. Kota Batu has 4 large and famous satay restaurants from 53 to 15 years ago. The survey conducted at the four satay restaurants (Mesir Restaurant, Pak Djumari, Sate Hotplate and Cairo Restaurant) showed that the average nutritional content of goat satay were 32.19 ± 0.00% for protein; 1.87 ± 0.60% for fat; 6.47 ± 0.05% for carbohydrates; 53.02 ± 1.04% for water and 2.21 ± 0.02% for ash. Meanwhile, the precursor compounds for HAA carcinogens in goat meat, the main ingredient of satay, were 3.86 ± 0.04% for reducing sugar; 20.73% for amino acids and 0.7 ± 0.2 mg/g for creatinine. The four satay restaurants use young goats less than 1 year old (all teeth are still milk teeth), both male or female. Female goat was preferred by 4 owners of satay restaurants. The meat cuts used for satay at all satay restaurants were tenderloin and upper leg, both fore and hind. The four satay restaurants use wood charcoal to grill the satay meat at an average temperature of 300°C for 2 to 5.5 minutes until well-done and slightly burnt. The three precursor compounds found in goat meat and the grilling temperature applied have the potential to produce HAA carcinogens in goat satay.

Keywords: satay; goat; nutritional; carcinogens; heterocyclic aromatic amine

INTRODUCTION

Satay is one of Indonesia’s national dishes along with rendang, soto, bakso and nasi goreng. These dishes can be found anywhere in Indonesia. Satay can be purchased from mobile vendors, street vendors, to restaurants. Satay is even a luxury dish of a wedding reception and has worldwide popularity nowadays, not only in Southeast Asian countries, such as Malaysia, Singapore, the Philippines and Thailand.

Behind the enjoyment of satay, it turns out that there are potential dangers of carcinogenic compounds that cause cancer. Satay is cooked by grilling method. Grilling is an important process for enriching nutritional quality, increasing digestibility and bioavailability of nutrients, extending shelf life, obtaining better sensory and functional properties, releasing bioactive components, producing beneficial compounds, destroying anti-nutritional substances and inactivation of pathogens (Van Boekel et al., 2010). However, this process also turns out to give rise to carcinogenic heterocyclic aromatic amines (HAA) and other byproducts that are potentially harmful to human health in the long run. Some other unintended consequences of food heating that have been thoroughly researched include: loss of certain nutrients (Halabi et al., 2020), formation of toxic compounds (Gomez-Narvaez et al., 2019) and production of compounds with negative effects on flavor, texture and color (Pang et al., 2019). In particular, the formation of potentially mutagenic and carcinogenic substances as a consequence of heating food processing has attracted a great deal of

115
attention in recent years. Some have been studied, for example: the formation of acrylamide (Bedade et al., 2019) and furan (Cepeda-Vazquez et al., 2018) in foods rich in carbohydrates, or acrolein (Ewert et al., 2014) or chloropropanediols (Li et al., 2016) in a diet rich in fat.

Until now, in Indonesia, there has never been any published research related to the HAA content in processed meat products. This is especially true for meat-based Indonesian traditional foods, such as satay, abon (meat floss) and dendeng (beef jerky), which are thermally processed. This study only evaluated the nutritional profile and HAA precursor compounds in goat satay which was most commonly sold in the community. This is to find out how much the potential dangers of HAA carcinogens in goat satay are consumed by the public so that prevention efforts can be made.

Skog et al. (2000) have reported that drastic heating conditions such as grilling and roasting can lead to significantly higher HAA content. The precursors for this group of polycyclic aromatic compounds are fundamental food components, namely reducing sugars, free amino acids and creatine/creatinine, which undergo a Maillard reaction to form HAA. More than two dozen HAAs have been identified in heat-treated foods. Wang et al. (2019) reported that several types of HAA have been classified as potential carcinogens for humans by the IARC (International Agency for Research on Cancer - WHO). HAA is a very significant risk to health due to the presence of HAA in most of our dietary components. There are ten HAAs that are currently considered carcinogens according to the IARC (Lili et al., 2019). They belong to two HAA groups. Four of them were in the HAA thermic or aminoimidazoazaren group and six of them were in the pyrolytic HAA group. The four aminoimidazoazarenes are: IQ [carcinogen, class 2A], as well as MeIQ, MeIQx, and PhIP [carcinogen, class 2B]. The six pyrolytic HAAs are: AcA, MeAcC, Glu-P-1, Glu-P-2, Trp-P-1, and Trp-P-2. According to Meurillon and Engel (2016), the pyrolytic HAA group is produced in negligible amounts under standard cooking conditions compared to aminoimidazoazaren. The carcinogenicity of HAA in cooked food is most likely due to the aminoimidazoazaren group HAA.

HAA is produced through the Maillard reaction, as the precursors involved, namely free amino acids, creatinine, and reducing sugars (glucose and fructose directly or by hydrolysis of sucrose). Previous model studies have shown that HAA formation is a consequence of the Maillard reaction because HAA is detected when the mixture is mixed. creatinine, specific carbohydrates and amino acids are heated at high temperatures (Zamora and Hidalgo, 2020).

The occurrence of the Maillard reaction is very important when meat is cooked because it produces a large number of compounds that contribute to the flavor of the meat. Most flavor compounds for roasted, boiled and meaty meat are produced through the Maillard reaction and generally contain heterocyclic nitrogen, sulfur and oxygen. Maillard's reaction was also hereditary it oxidizes by forming a brown coloration, and for this reason it is often referred to as a 'browning' or 'nonenzymatic browning' reaction. Substances that contribute significantly to the aroma profile of the overall cooked meat; includes: furan, furanone, pyrazine, pyrrole, thiophene, thiazole (thiazolone), imidazole, pyridine, oxazole, cyclic ethylene sulfide, alkyl sulfide and disulfide (Shahidi and Samaranayaka, 2004). The Maillard reaction can produce pyridine and pyrazine radicals, which then react with creatinine and an aldehyde to produce HAA with the structure of quinoline (IQ derivative) or quinoxaline (IQx derivative) (Vidal et al., 2020).

The rings in HAA are generated as a consequence of the tendency for reactive carbonyls to develop into aromatic rings. The pyridine and pyrazine rings are the key difference between the IQ and IQx type HAAs. This heterocyclic is known to form as a consequence of the carbonyl-amine reaction in food. The formation of the pyrazine ring is a known consequence of the Strecker degradation produced by α-dicarbonyl compounds during the Maillard reaction (Scalone et al., 2019). Pyridin is detected less frequently in the Maillard reaction process. However, pyridine is produced to a significant extent as a consequence of the carbonyl-amine reaction when reactive lipid-derived carbonyls are
involved (Zhang et al., 2018). Pyridin is produced due to cyclization and oligomerization of short-chain reactive aldehyde, lipid derivatives, which are formed in the presence of ammonia and ammonia-producing compounds. In fact, short-chain unsaturated aldehydes are unstable when heated in the presence of ammonia, and pyridine formation is observed rapidly (Zamora et al., 2020).

MATERIALS AND METHODS

This research was conducted from March to September 2020 at the Laboratory of Analytical Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Brawijaya. The goat meat and satay samples came from 4 of the biggest and most famous satay stalls in Batu City, East Java. Batu City is very crowded with domestic and foreign tourists, especially during the school holidays or weekends. In Batu City, many satays are sold, ranging from chicken satay, turkey satay, rabbit satay to goat/lamb satay. There are restaurants and mobile vendors that sell satay. The largest and most famous satay stalls that have been operating for more than 15 years in Batu City include: Warung Sate Hotplate, Rumah Makan Mesir, Warung Sate Pak Jumari and Rumah Makan Cairo. The research method was survey. The survey was carried out on these 4 satay restaurants which were purposely selected (purposive sampling method).

Protein analysis was performed by using the acid-base titration method and Khjeldal Nessler's reagent. Fat analysis was performed using gravimetric extraction methods and petroleum ether reagent. Analysis of carbohydrates was carried out by spectrophotometric methods and HCl reagent. Reducing sugar analysis was carried out by using the spectrophotometric method and Nelson's reagent. The analysis of ash and water content was carried out using the gravimetric method.

Data analysis using descriptive statistical methods. Descriptive statistics are statistical techniques that provide information only about the data held and do not intend to test the hypothesis and then draw generalized inferences for the larger data or population. This study used statistical methods that summarize, present and describe data in an easy-to-read form so that it provides convenience in providing information, descriptions and explanations of the data.

RESULTS AND DISCUSSION

Profile of Goat Satay Vendors

The goat satay vendors that was chosen deliberately were goat satay stalls that has been operating for more than 15 years, have permanent building and still gain popularity nowadays. The mobile and street vendors that open a stall with the shade of a portable tent were deliberately not made as respondents. At least in Batu City, which has a small area, there are 4 large goat satay restaurants, popular and crowded with local consumers and tourists. The four of them are arguably the middle and upper class goat satay restaurants whose consumers are more dominated by people who pay more attention to sanitation, hygiene, food safety and taste factors. Table 1 provides brief information on the four stalls.

All the satay restaurants use young goat (kid) meat (less than 1 year old). Generally, they prefer goat over lamb and prefer female goat to male goat. Their reason based on experience, is because sheep have more fat and female goats have more meat than male goats.

All the satay restaurants also use wood charcoal to grill the satay. The temperature of the coals for grilling satay reaches an average of 300°C and it takes 2 to 5.5 minutes to grill. All the satays are welldone and slightly burnt according to the general taste of their customers. The satay is served with peanut sauce along with some side dishes such as shallot slices, lemon slices and chili sauce. This has become a tradition from our ancestors that the serving of satay in Indonesia is always accompanied by chopped shallots, cabbage, bird eye chillies and sweet soy sauce. Behind this ancestral heritage, it turns out that it is useful to ward off free radicals and other carcinogens in the satay. This is because the complementary vegetables for the satay dish contain antioxidant compounds.
<table>
<thead>
<tr>
<th>Description</th>
<th>Mesir Restaurant</th>
<th>Pak Djamari</th>
<th>Sate Hotplate</th>
<th>Cairo Restaurant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Founder &amp; Owner</td>
<td>Family of H. Gattan Thalib and Hj. Gamar binti Abdul Khadir At Tamami (65 years)</td>
<td>Family of H. Djamari (65 years)</td>
<td>Family of H. Hasan Jumain (67 years) &amp; Drs. H. Muhammad Fanani (63 years)</td>
<td>H. Sholah Al Hadrami (70 years) &amp; Hj. Indun Al Hadrami (65 years)</td>
</tr>
<tr>
<td>Year of existence</td>
<td>1967 (53 years ago)</td>
<td>1980 (40 years ago)</td>
<td>1988 (32 years ago)</td>
<td>2005 (15 years ago)</td>
</tr>
<tr>
<td>Customer Service</td>
<td>(+62)341591214</td>
<td>(+62)85100378055</td>
<td>(+62)341593662</td>
<td>(+62)341596635</td>
</tr>
<tr>
<td>Operational time</td>
<td>08.00 - 22.00 WIB</td>
<td>14.30 - 21.00 WIB</td>
<td>08.00 - 21.00 WIB</td>
<td>08.00 - 21.30 WIB</td>
</tr>
<tr>
<td>Online Services</td>
<td>Gofood &amp; Grabfood</td>
<td>Gofood</td>
<td>Gofood &amp; Grabfood</td>
<td>Gofood</td>
</tr>
<tr>
<td>Size of raw mutton per cut</td>
<td>L: 1,5 – 2 cm; W: 1 – 1,5 cm; H: 0,5 cm</td>
<td>L: 1,5 – 2 cm; W: 1 – 1,5 cm; H: 0,5 cm</td>
<td>L: 2,5 – 3 cm; W: 1 – 2 cm; H: 0,5 cm</td>
<td>L: 2,5 – 3 cm; W: 1 – 1,5 cm; H: 0,5 - 1 cm.</td>
</tr>
<tr>
<td>Weight of raw mutton per skewer</td>
<td>17.8 ± 1,304 g</td>
<td>14.2 ± 0,748 g</td>
<td>20 ± 0 g</td>
<td>12.8 ± 1.924 g</td>
</tr>
<tr>
<td>Weight of lean goat satay per skewer</td>
<td>10.8 ± 0,837 g</td>
<td>12.8 ± 1,304 g</td>
<td>15 ± 0 g</td>
<td>9,6 ± 0,548 g</td>
</tr>
<tr>
<td>Cooking loss</td>
<td>39,303 ± 2,283 %</td>
<td>10,029 ± 4,409 %</td>
<td>25 ± 0 %</td>
<td>23,996 ± 8,744 %</td>
</tr>
<tr>
<td>Average grilling time</td>
<td>5 minutes</td>
<td>2,5 minutes</td>
<td>2 minutes</td>
<td>5,5 minutes</td>
</tr>
<tr>
<td>Grilling temperature</td>
<td>300 °C</td>
<td>300 °C</td>
<td>300 °C</td>
<td>300 °C</td>
</tr>
<tr>
<td>Cost for 1 serving (10 skewers without fat)</td>
<td>Rp 40.000,-</td>
<td>Rp 42.000,-</td>
<td>Rp 49.000,-</td>
<td>Rp 55.000,-</td>
</tr>
<tr>
<td>Estimated Turnover (Goat Satay Only)</td>
<td>- Weekend &amp; Holiday: Rp 35 Million</td>
<td>- Weekend &amp; Holiday: Rp 19 Million</td>
<td>- Weekend &amp; Holiday: Rp 44 Million</td>
<td>- Weekend &amp; Holiday: Rp 23 Million</td>
</tr>
<tr>
<td>Number of employees</td>
<td>5 employees</td>
<td>3 employees</td>
<td>10 employees</td>
<td>4 employees</td>
</tr>
<tr>
<td>The meat cuts used for satay</td>
<td>Sirloin, tenderloin and upper leg</td>
<td>Sirloin, tenderloin and upper leg</td>
<td>Sirloin, tenderloin, upper leg, shink and flank steak</td>
<td>Sirloin, tenderloin and upper leg</td>
</tr>
<tr>
<td>Gender of the slaughtered goat</td>
<td>Female / Male goats and sheep. Females are preferred.</td>
<td>Female / Male goats and sheep. Females are preferred.</td>
<td>Female / Male goats. Females are preferred.</td>
<td>Female goats</td>
</tr>
<tr>
<td>Age of the slaughtered goat</td>
<td>young (less than 1 year)</td>
<td>young (less than 1 year)</td>
<td>young (less than 1 year)</td>
<td>young (less than 1 year)</td>
</tr>
<tr>
<td>Carcass weight of the slaughtered goat</td>
<td>10-12 kg</td>
<td>10-16 kg</td>
<td>10-12 kg</td>
<td>10-18 kg</td>
</tr>
<tr>
<td>Price of goat carcass per kg</td>
<td>Rp 130.000,-</td>
<td>Rp 100.000,-</td>
<td>Rp 100.000,-</td>
<td>Rp 115.000,-</td>
</tr>
<tr>
<td>The capacity of dining chairs &amp; tables</td>
<td>35 people</td>
<td>20 people</td>
<td>250 people</td>
<td>100 people</td>
</tr>
<tr>
<td>The facilities of vehicle parking</td>
<td>Public facilities (on the side of the highway &amp; around the square)</td>
<td>Few &amp; public facilities (on the side of the highway)</td>
<td>There is enough &amp; restaurant property</td>
<td>Few &amp; public facilities (on the side of the highway)</td>
</tr>
<tr>
<td>Grilling spices</td>
<td>Gulai and Sweet ketchup</td>
<td>Gulai Soup, Sliced garlic &amp; Sweet ketchup</td>
<td>Gulai and Sweet ketchup</td>
<td>Gulai Soup, Garlic Juice, Grated Pineapple &amp; Sweet ketchup</td>
</tr>
<tr>
<td>Serving Complement</td>
<td>Sliced shallot, spice peanuts, chili peppers, half a lemon</td>
<td>Sliced shallot, spice peanuts, chili peppers, half a lemon</td>
<td>Sliced shallot, spice peanuts, chili peppers, half a lemon</td>
<td>Sliced shallot, spice peanuts and chili peppers</td>
</tr>
</tbody>
</table>
Acheampong et al. (2016) reported that shallots (Allium cepa var. Ascalonicum) contain total phenolic compounds between 0.001 - 0.124 TAE mg/25 g or 11.3% (w/w) (TAE = Tannic Acid Equivalents) in the form of: alkaloids, flavonoids, glycosides and tannins while saponins, terpenoids and anthraquione glycosides are absent. The total antioxidant capacity is 0.102 AAE mg/25 g (AAE = Ascorbic Acid Equivalents). The potential to reduce ferric content of shallots is 0.053 mg GAE/dry weight (GAE = Error Acid Equivalents) and its free radical scavenging activity (DPPH) is 63.41% at an extract concentration of 3 mg/mL. The minimum inhibitory concentration (IC₅₀) or the effective concentration that provides 50% of the maximum response of shallots 2.27 mg/mL or 1.60 mg GAE/dry weight.

Free radicals and other reactive intermediates especially carbonyl have been shown to be key participants in HAA formation. In accordance with this mechanistic basis, antioxidants have become the most important group of candidate HAA inhibitors. In the food system, these antioxidants are able to inhibit HAA formation even with low levels of addition (Wang et al., 2019). Ur Rahman et al. (2014) reported that antioxidants were very useful in eliminating HAA from fried meats and other high temperature cooked meats.

The price for 1 portion (10 sticks) of lean goat satay at 4 satay stalls ranges from IDR 40,000 to IDR 55,000. The weight of the goat satay ranges from 9.6 - 15 grams per stick or 96 - 150 grams per serving (10 sticks). The price of goat meat used for satay ranges from IDR 10,000 to IDR 13,000 per 100 grams.

**Nutrient Profile and HAA Carcinogen Precursor Compounds**

The following Table 2 presents the profile of the average levels of nutrients or nutrients and the average levels of HAA precursor compounds in goat meat. The levels of HAA precursor compounds consisting of reducing sugars, free amino acids and creatine/creatinine in goat meat were measured before grilling.

Young goat meat (less than 1 year old) which is used as the main raw material for goat satay in 4 large and well-known satay stalls in Batu City contains an average of 3.86 ± 0.04% reduced sugar content and an average protein content of 18.42 ± 0.11%.

| Table 2. Profile of Nutrients and HAA Precursor Compounds in Goat Meat and Satay |
|----------------------------------|--------|----------|--------|---------|----------|
|                                   | Reducing sugar | Carbohydrate | Protein | Fat     | Moisture |
| Goat meat                         | 3.86 ± 0.04   | Not measured | 18.42 ± 0.11 | 3.59 ± 0.00 | 69.17 ± 0.18 | 1.19 ± 0.02 |
| Satay                            | Not measured  | 6.47 ± 0.05  | 32.19 ± 0.00 | 1.87 ± 0.60 | 53.02 ± 1.04 | 2.21 ± 0.02 |

Notes: ± standard deviation; n = 4.

Protein levels correlate with levels of free amino acids in goat meat. According to literature studies, amino acids of goat meat contain the most glutamic acid and aspartic acid. Reducing sugars and amino acids are precursors for the Maillard reaction. The average temperature of wood charcoal coals used to roast goat satay in 4 sample satay stalls in Batu City reached a minimum of 300°C and the degree of doneness of the goat satay is well-done. The time used for grilling the goat satay on average ranges from 2 to 5.5 minutes depending on the amount of wood charcoal used.

The physiological function of creatine is to serve, in its phosphorylated form, as a high-energy phosphate reservoir which is then used to regenerate adenosine triphosphate during muscle contraction. This explains the relatively high creatine content in muscle compared to other tissues. Dahl (1965) confirmed the opinion of Hunter (1928) that creatine levels in lean meat are relatively constant. He found 0.74 to 3.28 g creatine per 100 g crude protein in adult animal skeletal muscle, but a narrower range (2.15 to 2.50) in cuts of meat without...
visible connective tissue. Because smaller amounts of creatine were found in meat samples with a higher connective tissue content, Dahl (1965) suggested that creatine levels as a percentage of crude protein could be used as an aid in evaluating restructured meat products.

Table 3. Goat Meat Amino Acid Profile

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male kids</td>
<td>Female kids</td>
<td></td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>13.43 ± 0.10</td>
<td>13.25 ± 0.29</td>
<td>3.16</td>
</tr>
<tr>
<td>Lysine</td>
<td>8.36 ± 0.31</td>
<td>8.11 ± 0.26</td>
<td>1.76</td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>7.65 ± 0.05</td>
<td>7.73 ± 0.30</td>
<td>2.03</td>
</tr>
<tr>
<td>Leucine</td>
<td>7.03 ± 0.22</td>
<td>6.83 ± 0.33</td>
<td>1.75</td>
</tr>
<tr>
<td>Arginine</td>
<td>5.53 ± 0.16</td>
<td>5.44 ± 0.09</td>
<td>1.44</td>
</tr>
<tr>
<td>Alanine</td>
<td>4.83 ± 0.07</td>
<td>4.82 ± 0.05</td>
<td>1.28</td>
</tr>
<tr>
<td>Threonine</td>
<td>4.64 ± 0.14</td>
<td>4.67 ± 0.12</td>
<td>0.91</td>
</tr>
<tr>
<td>Valine</td>
<td>3.97 ± 0.12</td>
<td>4.02 ± 0.16</td>
<td>1.19</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>3.93 ± 0.11</td>
<td>3.82 ± 0.16</td>
<td>1.03</td>
</tr>
<tr>
<td>Glycine</td>
<td>3.76 ± 0.26</td>
<td>3.91 ± 0.40</td>
<td>1.68</td>
</tr>
<tr>
<td>Serine</td>
<td>3.76 ± 0.02</td>
<td>3.79 ± 0.17</td>
<td>0.58</td>
</tr>
<tr>
<td>Penylalanine</td>
<td>3.63 ± 0.16</td>
<td>3.50 ± 0.15</td>
<td>0.91</td>
</tr>
<tr>
<td>Proline</td>
<td>3.15 ± 0.12</td>
<td>3.27 ± 0.22</td>
<td>0.74</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>3.07 ± 0.08</td>
<td>3.01 ± 0.15</td>
<td>0.63</td>
</tr>
<tr>
<td>Histidine</td>
<td>2.26 ± 0.14</td>
<td>2.44 ± 0.13</td>
<td>0.63</td>
</tr>
<tr>
<td>Methionine</td>
<td>2.22 ± 0.07</td>
<td>2.23 ± 0.07</td>
<td>0.49</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.99 ± 0.07</td>
<td>1.00 ± 0.03</td>
<td>0.22</td>
</tr>
<tr>
<td>Cystine</td>
<td>0.92 ± 0.01</td>
<td>0.94 ± 0.02</td>
<td>0.30</td>
</tr>
<tr>
<td>Total</td>
<td>83.13</td>
<td>82.78</td>
<td>20.73</td>
</tr>
</tbody>
</table>

Notes: Simela (2005) = Chevon, South Africa; Cempe jantan = temporary teeth; betina muda = the incisors are permanent a pair; Sheridan et al. (2003) = Cempe kambing Boer (135 hari).

As presented in Table 4, the creatinine levels of various cuts of meat of various livestock were found to vary from 0 to 24.5 mg per 100 g of fresh tissue; depending on muscle protein net but with greater variability. This constant ratio of creatine to net muscle protein can be a practical one as an index of meat quality. Total muscle protein net is used in West Germany as an indicator of meat quality under the name BEFFE ('Bindegewebeeiweissfreies Fleischeiweiss') and is described by analysis of total nitrogen and hydroxyproline. Creatine levels can be a simpler indicator of a meat quality index, at least for raw meat.

Likewise, it may be helpful in understanding urinary creatinine level as an index of lean body mass. Assuming that creatinine excretion depends on muscle mass, the excretion of creatinine (per kg body weight) is much less in infants and young children than in adults. Since the excreted creatinine comes from muscle creatine, its levels depend on muscle net protein rather than muscle mass, which in infants is lower because infantile muscle contains more collagen than adult cattle (Dvorak, 1981).

Creatine and creatinine are distinctive constituents of muscle tissue and the tests are used to detect the presence of meat extracts in food products. Raw meat has high creatine content (0.3 - 0.6% in fresh beef), while low creatinine content (about 6% of creatine) (Belitz and Grosch, 1987); therefore it is suitable to be used as an index of meat quality (Dvorak, 1987). However, when meat is cooked, creatine levels decrease while creatinine levels increase (Macy et al., 1970; Campero et al., 1992) so that total creatine levels (creatine + 1.159 creatinine) can be a better indicator of the quality of cooked meat products.
Table 4. Creatine and Creatinine Levels of Meat from Various Livestock

<table>
<thead>
<tr>
<th></th>
<th>Creatine</th>
<th>Creatinine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mg/100 g net muscle protein)</td>
<td></td>
</tr>
<tr>
<td>Pig</td>
<td>38</td>
<td>23.3 ± 1.4</td>
</tr>
<tr>
<td>Cattle</td>
<td>29</td>
<td>23.3 ± 1.5</td>
</tr>
<tr>
<td>Calf</td>
<td>10</td>
<td>22.7 ± 1.0</td>
</tr>
<tr>
<td>Goat/Sheep</td>
<td>10</td>
<td>22.7 ± 0.9</td>
</tr>
<tr>
<td>Mean</td>
<td>87</td>
<td>23.2 ± 1.4</td>
</tr>
</tbody>
</table>

Source: Dvorak, 1981

Previous studies of pork, beef and lamb cuts, have shown that the values of the ratio of creatine in muscle tissue to contractile muscle protein are in a narrow range (total creatine 20.5 - 25.9 mg per gram of contractile muscle protein) (Dahl, 1963; Kahn and Cowen, 1977; Dvorak, 1981). The percentage of creatinine from total creatine increases with heating (temperature and/or time) (Macy et al., 1970; Campero et al., 1992). This increase is due to the conversion of creatine to creatinine in slightly acidic conditions from meat which catalyzes the removal of water molecules from creatine to form creatinine (Edgar and Shiver, 1925). Therefore, the creatinine percentage of the total creatine can provide additional information about the heat treatment applied to the product. Several authors (Dahl, 1963; Kahn and Cowen, 1977; Dvorak, 1981) have suggested that the total creatine/net muscle protein ratio depends on the age and geographic origin of the animal.

HAA is produced through the Maillard reaction, as a precursor involved, namely free amino acids, creatinine, and reducing sugars (glucose and fructose directly or by hydrolysis of sucrose) (Hwang and Ngadi, 2002). Previous model studies have shown that HAA formation results as a consequence of the Maillard reaction because HAA is detected when a mixture of creatinine, specific carbohydrates and amino acids is heated to high temperatures (Skog et al., 1998). Because the Maillard reaction is involved in free radicals or reactive carbonyl, Zamora and Hidalgo (2020) proposed two main postulates for HAA formation, namely: the free radical pathway and the carbonyl pathway.

The occurrence of the Maillard reaction is very important when meat is cooked because it produces a large number of compounds that contribute to the flavor of the meat. Most flavor compounds for roasted, boiled and meaty meat are produced through the Maillard reaction and generally contain heterocyclic nitrogen, sulfur and oxygen. The Maillard reaction is also associated with browning, and for this reason it is often referred to as a 'browning' or 'nonenzymatic browning' reaction. The brown pigment, known as melanoidin, contains a variable amount of nitrogen and has different molecular weight and water solubility. The dark brown color of the roast is a key factor in consumer acceptance of this product. Several other changes in the characteristics of cooked meat can also be caused by Maillard-type reactions and include the production of bioactive compounds with beneficial effects (antioxidant properties) or toxic effects (e.g. imidazoles), decreased nutritional quality (especially protein) and modification of product texture. According to Shahidi and Samaranayaka (2004), the products formed from the Maillard reaction in a biological system depend on the temperature and time (duration) of cooking, water activity/moisture content and pH, as well as the nature and concentration of the reactants involved.

The increased formation of brown pigment (melanoidin) and low molecular weight flavor compounds in cooked foods was significantly associated with higher cooking temperatures. The optimum rate for the Maillard reaction occurs in water activity from 0.65 to 0.75. In other words, the Maillard reaction proceeds more easily under conditions of low moisture content, and the resulting flavor compounds are associated mostly with areas outside the meat that have been dehydrated during cooking. Most of the flavor compounds produced by the Maillard reaction are N-, S- and O-heterocyclics and other sulfur-containing compounds that give cooked meat a roasted, boiled, and meaty aroma. These compounds contribute significantly to the aroma profile of the overall cooked meat; includes: furan, furanone,
pyrazine, pyrrol, thiophene, thiazole (thiazoline), imidazole, pyridine, oxazole, cyclic ethylene sulfide, alkyl sulfide and disulfide.

HAA is produced as a consequence of free radical reactions produced in food as a consequence of processing (Pearson et al., 1992). The Maillard reaction can produce pyridine and pyrazine radicals, which then react with creatinine and an aldehyde to produce HAA with the structure of quinoline (IQ derivative) or quinoxaline (IQx derivative). This hypothesis is based on the presence of free radicals in this reaction, as shown through ESR studies (Stoesser et al., 2007), and also in studies of inhibition of HAA formation by phenolic antioxidants (Gibis and Weiss, 2012; Vidal et al., 2020).

The second proposed pathway is based on the well-known Maillard reaction ability of producing pyrazine and pyridine (to a lesser extent) (Sinesio et al., 2019; Wang et al., 2019). The reaction of pyridine or pyrazine with aldehyde and creatinine will be the origin of HAA which is different from the structure of IQ or IQx. The main reason for this hypothesis is the synthesis of MeIQ and MeIQx which is explained by the reaction of 2-methylpyridine or 2,5-dimethylpyrazine with creatinine and acetaldehyde (Milic et al., 1993).

To date, only one common pathway for HAA formation has been proposed, namely the formation of aminimidazoazaren PhIP. The description of this mechanism began nearly two decades ago (Zöchling and Murkovic, 2002), but has not been completed until recently (Zamora et al., 2014). Oddly, it doesn't follow the two paths described above. Heterocyclic rings are constructed in situ. This reaction is initiated by adding creatinine to the reactive carbonyl to give the appropriate aldol, which is then dehydrated. The formation of a pyridine ring will be produced by closing the ring from the adduct that is formed in the presence of ammonia and formaldehyde (Zamora et al., 2014). Ammonia and formaldehyde can also react between them to produce formamide (Reddy et al., 2019), which can act as an intermediate. Other types of aminimidazoazaren can also be produced similar to PhIP. Hence, their formation is a consequence of carbonyl chemistry, but not in the sense of the postulate previously described. By analogy to the PhIP observation, the rings (also heterocyclic rings) present in HAA can be formed by cyclization and oligomerization of the aldehyde under cooking conditions which are usually when the required reactants are present.

The rings in HAA are generated as a consequence of the tendency for reactive carbonyls to develop into aromatic rings. The pyridine and pyrazine rings are the key difference between the IQ and IQx type HAAs. This heterocyclic is known to form as a consequence of the carbonyl-amine reaction in food. The formation of the pyrazine ring is a known consequence of the Strecker degradation produced by α-dicarbonyl compounds during the Maillard reaction (Scalone et al., 2019). Pyridin is detected less frequently in the Maillard reaction process. However, they are produced to a significant extent as a consequence of the carbonyl-amine reaction when reactive lipid-derived carbonyls are involved (Zhang et al., 2018). This pyridine formation pathway has been proposed recently (Zamora et al., 2020). They are produced due to the cyclization and oligomerization of short chain reactive aldehyde derivatives of lipids which are formed in the presence of ammonia compounds and ammonia-producing compounds. In fact, short-chain unsaturated aldehydes are unstable when heated in the presence of ammonia, and pyridine formation is observed rapidly (Zamora et al., 2020).

According to Zamora and Hidalgo (2020), pyridin is always produced in the same way, although the resulting product is different, depending on the aldehyde involved. So, a mixture of alkanes and 2-alkenes gives 2-alkylypyridine. In particular, the formation of 2-methylpyridine occurs by adding ammonia to crotonaldehyde (R = CH₃), then an adduct reaction that is formed with acetaldehyde (R' = H). This new adduct undergoes cyclization, dehydration, and aromatization reactions respectively to produce the associated pyridine. This type of pyridine can also be produced by a 2,4-alkadienal cyclization reaction.

If the starting reactants are acrolein and alkanes, the product obtained is 3-alkylypyridine. Thus, the formation of 3-methylpyridine is produced by the reaction of acrolein (R = H) and propanal (R' = CH₃). The reaction begins again with the addition of ammonia to
acrolein and the formation of an imine associated with propanal. Cyclization, dehydration and oxidation of this adduct produce 3-methylpyridine.

When the right aldehyde is present in the presence of an ammonia compound and a compound that produces ammonia, the aldehyde will quickly produce a heterocyclic structure. However, when other compounds are present, these other compounds are also involved in the reactions that are formed and mixed adducts are usually produced. This happens, for example, in the presence of creatinine (Zamora and Hidalgo, 2020).

CONCLUSION

Batu City has 4 large and famous satay stalls from 53 to 15 years ago. The survey conducted at the four satay stalls (Egyptian Restaurant, Pak Djamari Sate Warung, Sate Hotplate Warung and Cairo Restaurant) showed that the average nutritional content of goat satay was 32.19 ± 0.00% for protein; 1.87 ± 0.60% for fat; 6.47 ± 0.05% for carbohydrates; 53.02 ± 1.04% for moisture and 2.21 ± 0.02% for ash. Meanwhile, the precursor compound for HAA carcinogens in goat meat, which is the main ingredient of satay, was 3.86 ± 0.04% for reducing sugar; 20.73% for amino acids and 0.7 ± 0.2 mg/g for creatinine. The four satay stalls use young goats (less than 1 year old), both male and female. The young female goats are preferred by the 4 satay stall owners. The cuts of meat used for satay at all satay stalls are the tenderloin, the front and rear thighs. The four satay stalls use wood charcoal to grill the satay meat at an average temperature of 300°C for 2 to 5.5 minutes until well-done and slightly burnt. The three precursor compounds found in goat meat and the roasting temperature applied have the potential to produce HAA carcinogens in goat satay.

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REFERENCES


