Caffeine Content of Bondowoso Arabica Ground Coffee with Variation of Roasting Profile and Type of Packages

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Abstract

Bondowoso Arabica coffee is a type of coffee that grows on the slopes of Mount Ijen-Raung. It has a high commercial value and distinctive taste. Coffee processing applications from roasting, grinding, packaging and brewing to storage will affect the quality of coffee. Caffeine is one of the compounds in coffee that contributes to bitterness and has certain pharmacological effects. This study aimed to determine the caffeine content of Bondowoso Arabica coffee harvested on August 2021 which was obtained from Sukosari Lor village with various roast profiles and types of packaging. In this study, Arabica coffee was roasted with light roast, medium roast and dark roast profiles. Then each treatment was mashed to obtain ground coffee. Ground coffee was put in a standing pouch made of polyethylene terephthalate (PET) with a thickness of 75 microns; polypropylene (PP) with a thickness of 100 microns; and polypropylene (PP) with a thickness of 120 microns and then stored for three months. During the storage of first and third months, caffeine levels were measured. Based on the results of the study, the caffeine content was increase along with higher roasting temperature. During the storage process, the caffeine content in ground coffee packaged using PP decreased the most.

Keywords: caffeine, coffee, packaging,

INTRODUCTION

Coffee is a commodity that an important role globally (Wibowo *et al.*, 2021).
Arabica coffee (*Coffea arabica* L.) is a type of coffee that has high commercial value and has a more favorable taste than Robusta coffee (Dias & Benassi, 2015; Randriani *et al.*, 2018). Arabica coffee plantations in the highlands produce the best tasting coffee (Randriani *et al.*, 2018).

Arabica coffee in Bondowoso is called as Java Ijen-Raung Arabica Coffee (Wibowo *et al.*, 2021). Java Ijen-Raung coffee has a good development prospects, one of which is through processing into ground coffee (Ardila *et al.*, 2019; Cristanto *et al.*, 2018; Suradi *et al.*, 2017).

Types of coffee roast profiles are generally classified visually by the color of the coffee beans formed as a result of the roasting process at a certain temperature and time (Anisa *et al.*, 2017; Bicho *et al.*, 2012; Fadri *et al.*, 2019;

light, medium, and dark. Roasted coffee has
several levels of color. Furthermore, the degree of roasting of coffee based on the popping sound when roasted is categorized into light (beginning of first crack), medium (peak of first crack), medium-dark (beginning of second crack), dark roast (end of second crack) (Tarigan *et al*., 2022).

Coffee processing starting from roasting, grinding, packaging and brewing methods will affect the quality of coffee. During this stage, changes in coffee quality can occur which result in loss of aroma and freshness of flavor. This phenomenon is referred to as staling, namely the presence of a sweet but unpleasant taste and aroma due to the loss of various volatile compounds. Lipid degra- dation due to lipolysis and lipid oxidation also contributes to the decline in coffee quality (Andayani & Agustini, 2019).

Roasting is reported to affect the physical and chemical properties of coffee. Factors that have an important effect on coffee roasting are roasting time and temperature where these two factors will directly affect the water content, carbohydrates, protein, and levels of phenolic compounds which then have an impact on consumer acceptance (Mehaya & Mohammad, 2020; Wang, 2012).

During storage, there can be a transfor- mation of the chemical content of coffee that is triggered by the roasting process and the susceptibility of roasted coffee to physical and chemical changes will affect the sensory quality of the brewed coffee. Water

storage for a certain period of time (Edowai & Tahoba, 2018; Saolan *et al*., 2020).

The freshness of ground coffee can be maintained by using the right type of packaging with good oxygen permeability (Tarigan *et al*., 2021). Several types of packaging materials that are often used are packaging made of aluminum, LDPE (low density polyethylene), PET (polyethylene terephthalate), PVC (poly- vinyl chloride), nylon, PS (polystyrene) and PP (polypropylene) (Dharmaputra *et al*., 2021; Kiyoi, 2010). Some home industry of coffee processing in Bondowoso are common to use plastic package to pack and sell ground coffee in relatively short time. The use of plastic package for home industry is known to be more priceless and practical.

Caffeine is commonly found in human daily intake, since it is also added in food, beverages, and supplements in various form (Dam *et al*., 2020). Caffeine (1,3,7-trimethyl- xanthine) is one of the secondary plant metabolite in coffee that contributes to bitterness and has certain stimulating effects on the center of nervous system (Franca *et al*., 2005; Olechno *et al*., 2021). Caffeine is a heterocyclic organic compound with xanthine as a purine base, comprised of a pyrimidine ring associated to an imidazole ring. Caffeine is colorless at ambient temperature, odorless, and bitter (Farah & dePaula, 2019). Arabica green bean commonly performed lower caffeine level than Robusta green bean (Caracostea *et al*., 2021; Fadri *et al*., 2020; Yu *et al*., 2021).

MATERIALS AND METHODS

Arabica Coffee Roasting and Grinding

The Arabica green bean used is a specialty commodity of Java Arabica Coffee which was obtained from Sukosari Lor village, Sukosari sub-district, Bondowoso, East Java, Indonesia. The coffee cherries were processed by applying a natural process. The Arabica green beans obtained, were then roasted. Roasting involves a combination of time and temperature that alters the structure and chemical properties of coffee beans by means of pyrolysis process (Fikri *et al.*, 2022). The roasting process is crucial to develop color, flavor, and aroma of coffee (Santoso *et al.*, 2021).

The coffee roasting process is carried out by applying a drum type roaster with a capacity of one kilogram of coffee per batch. The roaster is equipped with an exhaust fan, thermocouple and data logger. The achieve- ment of each roast profile is distinguished by temperature and roasting time. Roasted coffee profiles in this study were categorized into light roast, medium to dark roast and dark roast. After roasting,

Storage of Ground Coffee

Arabica ground coffee was then stored for three months at room temperature. Three months of storage was chosen in order to simulate the home industry treatment for coffee processing, which commonly using plastic packaging for short period of selling. The package of ground Arabica coffee included of three variations of standing pouch ziplock packaging: a. PET material (75 micron), b. PP material (100 micron), and c. PP material (120 micron). Each treatment were replicated three times. During storage

measured. The caffeine level were also mea-

Caffeine Level Measurement

Measurement of caffeine content of Arabica coffee with light, medium-dark and dark roast profiles was carried out at the beginning and three months after the storage of Arabica ground coffee. The procedure for measuring the caffeine content of ground coffee is carried out by referring to Indone- sian National Standard (SNI) 01-3542-2004, namely the determination of caffeine using the Bailey-Andrew method (BSN, 2004; Government of India, 2005).

The determination of caffeine using the Bailey-Andrew method was carried out by weighing the sample that had been finely ground and passed a 30 mesh sieve as much as 5 g, then put into an Erlenmeyer. Into the Erlenmeyer, 5 g of MgO and 200 mL of distilled water were added. After being covered with cooling back then simmer slowly for 2 hours. After cooling, it is diluted with distilled water in a measuring flask so that the volume is exactly 500 mL, then filtered. 300 mLof filtrate was taken and put into a
flask, added 10 mL of H_2SO_4 (1:9), then boiled until the liquid v olume remained approximately 100 mL. The liquid is put into a separating funnel. The flask was rinsed with a small amount of sulfuric acid (1:99) and shaken with chloroform. This rinse liquid is put into a separatory funnel. Into the separatory funnel, 5 mL of 1% KOH was added then shaken and left for some time until the liquid separated clearly. The bottom liquid is a solution of caffeine in chloroform, removed and stored in an Erlenmeyer. Into the separatory

repeated once again. The caffeine solution
in chloroform is then heated in a water bath so that the residue remains, then dried in an oven at 100°C until a constant weight is obtained which is the weight of crude caffeine.

$$\text{Calculation} \quad _8 \quad _{10} \quad _4 \quad _2$$
$$= \text{g N x } 3{,}464 \text{ x } 500/300$$

Data Analysis

In order to investigate the effect of various roasting profiles and type of packages on caffeine content of Bondowoso Arabika coffee beans, all the treatments and mea- surements were performed in triplicates. The data obtained were then presented in Tables and Graphs.

RESULTS AND DISCUSSION

Roasting Conditions

Based on Table 1, it is known that the initial roasting temperature of Arabica coffee with light roast, medium roast and dark roast profiles were 178°C, 180°C, and 182°C, respectively. The final roasting temperature for Arabica coffee with light roast, medium roast and dark roast profiles were 208°C, 215°C, and 223°C, respectively. During roasting, the coffee loses weight, which ranges from 9.8% to 14.3%. The largest weight loss occurred in coffee roasted with a dark roast profile (14.3%), while the

a light roast profile (9.8%). This is in line with other studies which reported that coffee roasted at temperatures of 210, 220, 230, 240 and 250°C experienced a weight loss of
8.54%; 11%; 12.74%; 18.12%; and 24.27%, respectively (Cuong *et al.*, 2014). During coffee roasting, heat and mass are transferred simul- taneously as in the drying process (Joko *et al.*,
2009). The roasting process causes water loss and volatile compounds that have an impact on the weight loss of the roasted coffee. The longer the roasting process and the higher the roasting temperature, this will have

Effects of Temperature

Coffee is one of the plantation products that
contain caffeine. Caffeine is a type of alkaloid found in coffee beans, tea leaves and cocoa beans (Fajriana & Fajriati, 2018). Changes in caffeine content with differences in roasting temperature are presented in Figure 2. Based on the figure, it is known that along with the increase in roasting temperature, there will be an increase in caffeine content, which was 3.75% at 167°C; 3.88% at 177°C and 3.95% at 188°C. However, the change in caffeine content in each treatment did not appear too large. Caffeine is a stable compound and degrades slightly when roasted. In an- other study, it was reported that 230°C is the optimum temperature for dark roast coffee to retain several bioactive compounds. Caffeine tends to be

Table 1. Variables observed during the roasting process of Bondowoso Arabica coffee

Variables	Light roast	Medium to dark roast	Dark roast
Initial temperature (°C)	178	180	182
Final temperature (°C)	208	215	223
Average temperature (°C)	167	177	188
Weight loss (%)	9.8	12.5	14.3
Roasting time (minutes)	12	12	12

Analysis using Differential Scanning Calorimetry (DSC) from another report showed that caffeine releases water during the roasting process and changes to the anhydrous state which is a more thermally stable structure. Further analysis of X-Ray Diffraction (XRD) showed the presence of a crystal structure for the caffeine fraction.

Roasted coffee has both amorphous and crystalline regions. The significant difference in this spectrum is evidence of a change in the distribution of the amorphous to crys- talline phase when coffee is subjected to thermal treatment. Caffeine in the ⊣ -poly- morph form changes to the ⊵ -crystal

Caffeine content during storage

Caffeine is a compound that is naturally present in coffee beans along with 60 other plant parts such as tea leaves, cola nuts, cocoa beans etc. It is an alkaloid in nature and its chemical name is 1,3,7-trimethylxanthine (Asmari *et al.*, 2020). The caffeine content

Bondowoso Arabica coffee roasted with light roast, medium roast and dark roast profiles were 3.75, 3.88, and 3.95%, respectively. Based on the results of this analysis, it is known that Bondowoso Arabica coffee with natural processing will have caffeine levels that increase along with the increase in roasting degree. This is in line with the results of another study where roasting treatment was reported to increase caffeine levels in Ilu Abba Bora coffee, Southwest Ethiopia (Motora & Beyene, 2017). Then it was also reported that along with the increase in the degree of roasting, this has an impact on the increasing of caffeine content in Vietnamese Robusta coffee which was roasted with an American Roast to Spanish Roast profile and using a temperature variation of 210-250°C. (Cuong *et al.*, 2014). It was also reported that green coffee roasting caused an increase in caffeine levels in coffee roasted with a light profile (1.96%) and medium (2.03%), but caused a decrease in caffeine levels in coffee with a dark roast profile
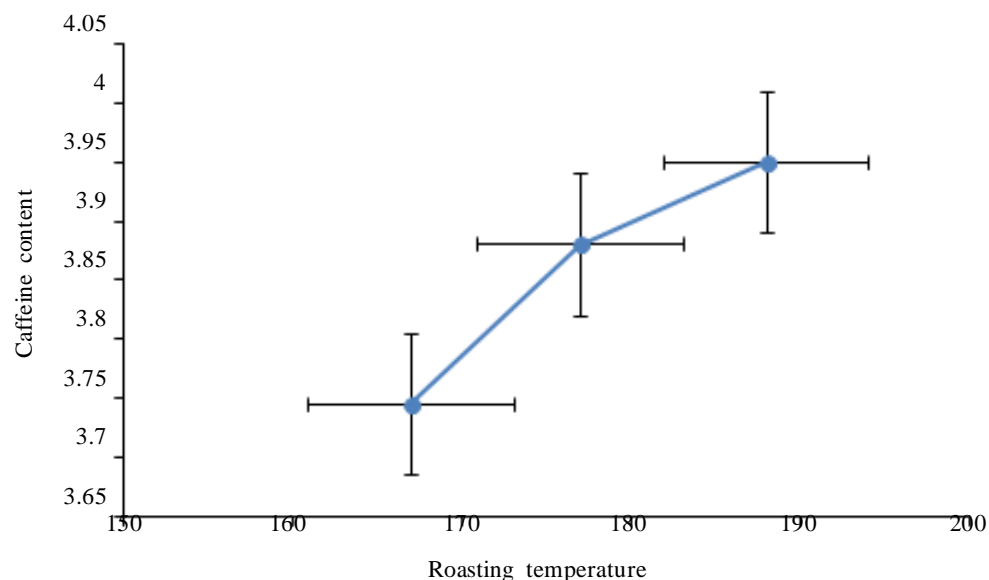

Figure 1. Relationship between roasting temperature and caffeine content of Bondowoso Arabica ground coffee

et al., 2005). An increase in temperature can

reduce the moisture content in coffee beans, so that it can help release volatile compounds (eg, caffeine) from coffee; because the caffeine content in dark roast coffee was significantly reduced compared to light roast and me- dium roast coffee after the roasting tem- perature increased to a higher limit (dark roast) (Awwad *et al.*, 2021).

Furthermore, Arabica ground coffee stored for three months showed a decrease in caffeine content (Figure 2). Coffee stored in PP packaging with a thickness of 120 microns showed a decrease in caffeine content from 3.745% to 3.635% (light roast profiles); from 3.88% to 3.77% (medium roast profiles); and from 3.95% to 3.905% (dark roast profiles). This phenomenon is also supported by another study which showed a decrease in caffeine levels in natural processed green beans stored at 20°C for three months, from 1709 mg 100 g^{-1} to 1551

Polyethylene terephthalate (PET) is a

type of polyester formed by the reaction between dimethyl terephthalate and ethylene glycol. PET has properties as a good barrier against gases, moisture, heat, mineral oil, solvents and acids (Andayani & Agustini,

2019).

Polypropylene (PP) plastic is a type of flexible plastic packaging that has good resistance to water, strong, lightweight, quite good at holding oxygen, transparent, has a price that tends to be cheap, and easily obtained in the market (Lobo *et al.*, 2014). PET is a good type of plastic as an oxygen barrier medium (Kirwan *et al.*, 2011). PP plastic has excellent moisture barrier characteris- tics (Kumar *et al.*, 2022). In this study, the largest decrease in caffeine levels occurred in ground coffee stored in packaging made of PP with a thickness of 120 microns, while packaging made from PET with a thickness
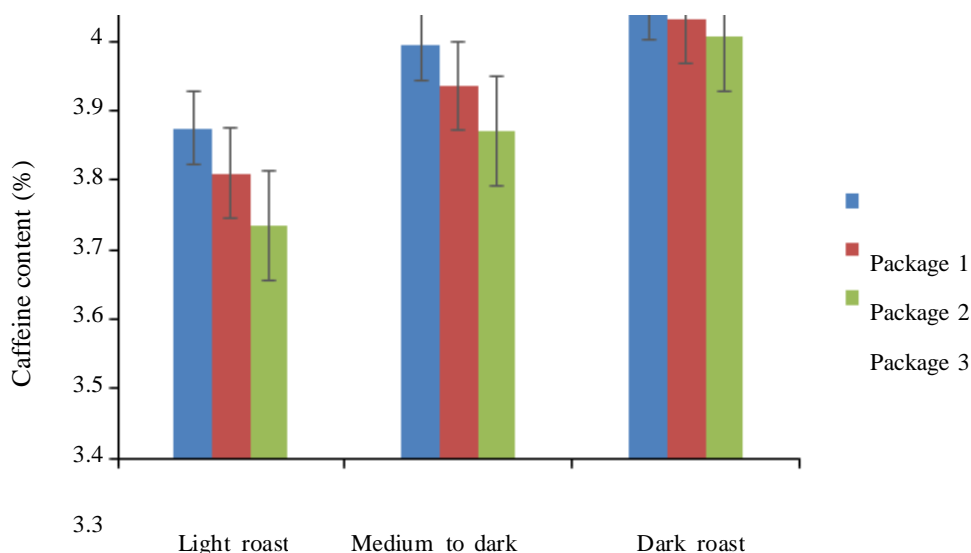

Figure 2. Effect of packing type and roasting type on caffeine content after 3 months of storage

Notes: Types of standing pouch ziplock packaging, including package 1: PET material with a thickness of 75 microns, package 2: PP material with a thickness of 100 micron, and package 3: PP material with a thickness of 120 micron.

volatile components of coffee occured. PP

packaging is not good as an oxygen barrier media so it provides an interaction between volatile coffee compounds and air containing oxygen and resulted in a decrease in caffeine levels. Oxygen is an element that is reported to accelerate the rate of product damage re- actions, starting from triggering microbial growth, denaturation of vitamins, damage to pigments, enzymatic browning processes

CONCLUSIONS

In this experiment, the Bondowoso Arabica coffee roasted by higher temperature un- derwent higher weight loss. Roasting cof- fee using higher temperature resulting a higher caffeine level in Bondowoso Arabica coffee. During the storage process there was a decrease in caffeine content, especially in ground coffee packaged using polypropy- lene (PP) rather than ground coffee pack- aged

REFERENCES

Andayani, O. & S. Agustini (2019). Penentuan masa simpan kopi bubuk dalam kemasan aluminium laminated polyetilen (ALP) dan poly etilen ptalat (PET). *Jurnal Dinamika Penelitian Industri*, 30(2).

Anisa, A.; W.K. Solomon & A. Solomon (2017). Optimization of roasting time and tempera- ture for brewed hararghe coffee (*Coffea arabica* L.) using central composite design. *International Food Research Journal*, 24(6), 2285–2294.

Ardila, D.D.; T. Agustina & S. Subekti (2019). Saluran dan margin pemasaran kopi cap lereng tancak Kabupaten Bondowoso. *SEPA: Jurnal Sosial Ekonomi Pertanian dan Agribisnis*, 15(2), 116–127.

Asmari, K.; I.A. Zeid & A. Al-attar (2020). Medicinal properties of arabica coffee (*Coffea arabica*) oil: An overview. *Advance- ments in Life Sciences*, 8(1), 20–29.

Awwad, S.; R. Issa; L. Alnsour; D. Albals & I. Al-Momani (2021). Quantification of caffeine and chlorogenic acid in green and roasted coffee samples using HPLC-DAD and evaluation of the effect of degree of roasting on their levels. *Molecules*, 26, 7502.

Bicho, N.C.; A.E. Leitão; J.C. Ramalho; N.B. De Alvarenga & F.C. Lidon (2011). Iden- tification of nutritional descriptors of roasting intensity in beverages of Arabica and Robusta coffee beans. *International Journal of Food Sciences and Nutri- tion*, 62(8), 865–871.

Bicho, N.C.; A.E. Leitão; J.C. Ramalho & F.C. Lidon (2012). Use of colour parameters for roasted coffee assessment. *Ciencia e Tecnologia de Alimentos*, 32(3), 436–442.

BSN (2004). *Kopi Bubuk SNI 01-3542-2004.* Standar Nasional Indonesia, 1. Badan Standarisasi Nasional. Jakarta, Indonesia.

Caracostea, L.-M.; R. Sîrbu & F. Busuricu (2021). Determination of caffeine content in Arabica and Robusta green coffee of Indian origin. *European Journal of Natural Sciences and Medicine*, 4(1), 69–79.

Cristanto, A.D.H.D; Soetriono & J.M.M. Aji (2018). Kajian sistem agribisnis kopi Arabika di Desa Sukorejo Kecamatan Sumberwringin Kabupaten Bondowoso. *Jurnal Bioindustri*, 1(1), 50–59.

Cuong, T.V; L.H. Ling; G.K. Quan; S. Jin; S.S. Jie; T.L. Linh & T.D. Tiep (2014). Effect of roasting conditions on concentration in elements of Vietnam Robusta coffee. *Acta Universitatis Cibiniensis. Series E: Food Technology*, 18(2), 19–34.

Cuong, T.V.; L.H Ling; G.K Quan.; T.D. Tiep; X. Nan; C.X. Qing & T. Le. Linh (2014). Effect of roasting conditions on several chemical constituents of Vietnam Robusta coffee. *Food Technology*, 38(2), 43–56.

Dam, R.M.V; Frank & W.C Willet (2020). Coffee, caffeine, and health. *The New England Journal of Medicine*, 383(4), 369–378.

Dharmaputra, O.S.; S. Ambarwati; I. Retnowati & N. Nurfadila (2021). Assessment of the quality of Arabica coffee beans from three processing methods and two types of packaging materials. *Biotropia*, 28(3), 193–203.

Dias, R.C.E. & M. de T Benassi (2015). Discrimination between Arabica and Robusta coffees using hydrosoluble compounds: Is the efficiency of the parameters dependent on the roast degree? *Beverages*, 1(3), 127–139.

Edowai, D.N. & A.E. Tahoba (2018). Proses produksi dan uji mutu bubuk kopi Arabika (*Coffea arabica* L) asal Kabupaten Dogiyai, Papua. *Agriovet*, 1(1), 1–18.

Fadri, R.A.; K. Sayuti; N. Nazir & I. Suliansyah (2019). Review proses penyangraian kopi dan terbentuknya akrilamida yang berhubungan dengan kesehatan. *Journal of Applied Agricultural Science and Technology*, 3(1), 129–145.

Fadri, R.A; K. Sayuti; N. Nazir & I. Suliansyah (2020). Analysis of caffeine levels in the beverages of roasted Arabica coffee Balango in Bukik Apik with the method of Spectroscopic. *IOP Conference Series: Earth and Environmental Science*, 515(1).

Fajriana, N.H. & I. Fajriati (2018). Analisis kadar kafein kopi Arabika (*Coffea arabica* L.) pada variasi temperatur sangrai secara spektrofotometri ultra violet. *Analit: Analytical and Environmental Chemistry*, 3(02), 148–162.

Farah, A. & J. dePaula (2019). Caffeine consumption through coffee: Content in the beverage, metabolism, health benefits and risks. *Beverages*, 5(37), 1–51.

Fikri, A.M.K; T. Prihandono & L. Nuraini (2022). Pengaruh suhu dan lama waktu roasting terhadap massa jenis biji kopi Robusta menggunakan mesin roasting tipe hot air. *Jurnal Pendidikan MIPA*, 12(2), 249–254.

Franca, A.S.; J.C.F. Mendonça & S.D. Oliveira (2005). Composition of green and roasted coffees of different cup qualities. *LWT - Food Science and Technology*, 38 (7), 709–715.

Government of India (2005). *Manual of Methods of Analysis of Foods (Coffee, Tea, Cocoa, Chicory) Sugar And Sugar Products And Confectionery Products*. New Delhi, India.

Grzelczyk, J.; P. Fiurasek; A. Kakkar & G. Budryn (2022). Evaluation of the thermal stability of bioactive compounds in coffee beans and their fractions modified in the roasting process. *Food Chemistry*, 387, 1–11.

Hadisoemarto, T. (2003). Penyerap oksigen dan aplikasinya dalam sistem pengemasan untuk memperpanjang umur simpan produk pangan yang dikemas. *Bulletin Penelitian*, 25(2), 1–9.

Ivorra, E.; J.C.S. González & J.G. Hernández (2020). Computer vision techniques for modelling the roasting process of coffee (*Coffea arabica* L.) var. Castillo. *Czech Journal of Food Sciences*, 38(6), 388–396.

Joko, N.; J. Lumbanbatu & R. Sri (2009). Pengaruh suhu dan lama penyangraian terhadap sifat fisik-mekanis biji kopi Robusta. *Seminar Nasional dan Gelar Teknologi PERTETA*, 6, 217–225.

Kirwan, M.J.; S. Plant & J.W. Strawbridge (2011). Plastics in food packaging. *Food and Beverage Packaging Technology: Second Edition*, 157–212.

Kiyoi, L. (2010). *Determining the Optimal Material for Coffee Packaging*. BSc Thesis. California Polytechnic State University, San Luis Obispo, USA.

Kreuml, M.T.L.; D. Majchrzak; B. Ploederl & J. Koenig (2013). Changes in sensory quality characteristics of coffee during storage. *Food Science and Nutrition*, 1(4), 267–272.

Kumar, V.; A.K. Vinayak; S. Venkatachalam & L. Muruganandam (2022). Moisture barrier behavior of polymer films on food packaging plastic materials. *International Journal for Technological Research in Engineering*, 9 (5), 6–12.

Lobo, Y.A.; P.K.D. Kencan & G. Arda (2014). Studi pengaruh jenis kemasan dan ketebalan plastik terhadap karakteristik mutu rebung bambu tabah (*Gigantochloa nigrociliata* kurz) kering. *Jurnal Beta*, 2(1), 1–10.

Mehaya, F.M. & A.A. Mohammad (2020). Thermostability of bioactive compounds during roasting process of coffee beans. *Heliyon*, 6 (11), e05508.

Motora, K.G. & T.T. Beyene (2017). Determination of caffeine in raw and roasted coffee beans of Ilu Abba Bora Zone, South West Ethiopia. *Indo American Journal of Pharmaceutical Research*, 7 (09), 463–470.

Olechno, E.; A.P. Jakubik; M.E. Zujko & K. Socha (2021). Influence of various factors on caffeine content in coffee brews. *Foods*, 10 (1208), 1–29.

Purnamayanti, N.P.A.; I.B.P. Gunadnya & G. Arda (2017). Pengaruh suhu dan lama penyangraian terhadap karakteristik fisik dan mutu sensori kopi Arabika (*Coffea arabica* L). *Jurnal BETA Biosistem dan Teknik Pertanian*, 5(2), 39–48.

Randriani, E; D. Dani & E. Wardiana (2018). Atribut mutu empat kultivar kopi Arabika pada ketinggian tempat tumbuh dan metode pengolahan yang berbeda. *Jurnal Tanaman Industri dan Penyegar*, 5(1), 21.

Saloko, S.; Y. Sulastri; Murad & M.A. Rinjani (2019). The effects of temperature and roasting time on the quality of ground Robusta coffee (*Coffea robusta*) using gene café roaster. *AIP Conference Proceedings*, 2199.

Santoso, I.; S.A. Mustaniroh & A. Choirun (2021). Methods for quality coffee roasting degree evaluation: A literature review on risk perspective. *IOP Conference Series: Earth and Environmental Science*, 924(1).

Saolan; A. Sukainah & M. Wijaya (2020). Pengaruh jenis kemasan dan lama waktu penyimpanan terhadap mutu bubuk kopi Robusta (*Coffea robusta*). *Jurnal Pendidikan Teknologi Pertanian*, 6(2), 337–338.

Suradi, I.; A. Murdyastuti & H.B. Patriadi (2017). Implementasi kebijakan pengembangan klaster kopi Arabika di Kabupaten Bondowoso. *Majalah Ilmiah Dian Ilmu*, 17(1), 54–73.

Tarigan, E.B; E. Wardiana & H. Supriadi (2021). Pengujian umur simpan kopi Arabika bubuk pada jenis kemasan dan suhu simpan yang berbeda. *Jurnal Tanaman Industri dan Penyegar*, 8(1), 37.

Tarigan, E.B.; E. Wardiana; Y.S. Hilmi & N.A. Komarudin (2022). The changes in chemical properties of coffee during roasting: A review. *IOP Conference Series: Earth and Environmental Science*, 974(1), 1–8.

Wang, N. (2012). *Physicochemical Changes of Coffee Beans During Roasting*. Ph.D Thesis. University of Guelph, Canada.

Wibowo, Y.; B.H. Purnomo & A. Kristio (2021). The agroindustry development strategy for Java Ijen-Raung Arabica coffee, in Bondowoso Regency, East Java. *Industria: Jurnal Teknologi dan Manajemen Agroindustri*, 10(2), 135–148.

Yu, Z.; A.J. Reddy & H. Wagh (2021). Determining the efficiency and yield of caffeine extraction for Robusta and Arabica coffee beans. *Applied Cell Biology*, 9 (3), 75–80.

Zarebska, M.; N. Stanek; K. Barabosz; A. Jaszkiewicz; R. Kulesza; R. Matejuk; D. Andrzejewski; L. Bi³os & A. Porada (2022). Comparison of chemical compounds and their influence on the taste of coffee depending on green beans storage conditions. *Scientific Reports*, 12(1), 1–12.

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