Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.118522

Characteristics of commercial single-origin organic coffee in Indonesia

Wahyudi DAVID[1], Mella INTANIA[1], Purba PURNAMA[2], Ihsan ISWALDI[2*]

Abstract

The increasing enthusiasm for single-origin coffee consumption creates a challenge regarding identification of its traceability. This study is the early stage for identifying the single-origin footprint that allow consumer detected the specific attribute. This study determines the dominant sensory attributes of eight commercial single-origin organic coffees using projective mapping (Napping®). The responses of 20 naive panelists who evaluated samples with a home-use test (HUT) were analyzed. The results showed that all samples had a unique dominant attribute determined by aroma, flavor, aftertaste, body, and acidity. Samples with aroma sweet and floral, flavor of sweet and nutty is most preferable. Most of the panelist prefer light medium in acidity and light for body as well as bitter and sour for aftertaste. This study was able to identify specific groups of attributes based on its origin of location. However, this study unable to identify original factor how the attribute was differs. The mapping of these attributes may be used to further study the coffee's traceability.

Keywords: organic coffee; multiple factor analysis; preference mapping; sensory; single origin.

Practical Application: By identifying the sources of a single-origin coffee's distinctive sensory attributes, the traceability of its origin can be developed using preference mapping, sensory wheels, and hierarchical clustering and specific or dominant sensory attributes.

1 Introduction

Coffee is one of the most traded commodities in the world. The annual world coffee consumption was estimated to be over 10,000 t in 2019-2020 (International Coffee Organization, 2021). Respective nutritional and phytochemical composition of coffee and coffee byproducts generated along the coffee production chain from harvest to brewing, stimulate more investigations into their role of affecting human physiological function and can be used in different ways in the food and pharmaceutical industries (Doepker et al., 2022; Gemechu, 2020). In the last decade, consumers' awareness of coffee attributes has increased owing to its rich flavor. The rise of third-wave coffee was marked by the beginning of coffee drinkers' interest in the coffee itself (Skeie, 2003). In addition to enjoying the sensory attributes of the coffee, consumers increasingly care about where the coffee is from, how the coffee was produced and how it is served. Single-origin organic coffee provides consumers a variety of distinct coffee choices.

Organic coffee, which is produced using an organic farming system without the aid of artificial chemical substances such as certain additives or some fertilizers, herbicides, and pesticides, has an important role in the economies of coffee-producing countries, including Indonesia. The global organic coffee market is estimated to reach $20.78 billion by 2030, growing by 10.6% annually from 2020 to 2030, due to the increase in consumption of healthy and organic products (GMD Research, 2021). Organically grown coffee beans contain higher concentrations of total phenols and phenolic compounds as compared to conventional coffee beans (Król et al., 2020). Moreover, labeling food products as organic tends to positively impact overall liking scores (Fernqvist & Ekelund, 2014; Schouteten et al., 2019).

Differences in the type of coffee bean, geographical location, level of roasting and method of preparation produce coffee of varying aroma, taste, and flavor (Persaud et al., 1999; Vitzthum, 1999). Single-origin coffee is a specialty coffee that contains unique characteristics based on the region in which it was produced, without having influences from other flavors or regions. Such coffee allows the consumer to experience a pure and exclusive taste. Bressani et al. (2021) have studied how consumers understand specialty coffees and their perspectives on the beverage. Single-origin organic coffee refers to coffee that is cultivated organically and sources from a single producer, crop, or region in one country. The crucial feature of single-origin organic coffee is traceability (Kamiloglu, 2019; Mercanta, 2021). By identifying the sources of a single-origin coffee's distinctive sensory attributes we could develop traceability of its origin using its dominant and specific sensory attributes. Currently, little is known about the sensory attributes of single-origin organic coffee from Indonesia. Therefore, the present study is early stage to identify the single origin-organic coffee by evaluating the sensory characteristics based on its location in Indonesia.

Received 28 Oct., 2022
Accepted 12 Dec., 2022
[1] *Department of Food Science and Technology, Universitas Bakrie, Jakarta, Indonesia*
[2] *Department of Food Technology, Universitas Prasetiya Mulya, Tangerang, Indonesia*
*Corresponding author: ihsan.iswaldi@prasetiyamulya.ac.id

2 Materials and methods

2.1 Sensory profile analysis

This research was conducted following International Organization for Standardization for Sensory analysis-Methodology-General Guidance for Establishing a Sensory Profile (International Organization for Standardization, 2003) as well as ISO for Sensory Analysis-Methodology-General Guidance for Conducting Hedonic Tests with Consumers in a Controlled Area (International Organization for Standardization, 2014). Panelists were selected based on a questionnaire and availability. All panelists provided informed consent. The testing was conducted with a home-use test (HUT). Panelists were informed of the procedure ahead of time and samples were sent to the panelists before the test. Responses from the panel were translated from Bahasa Indonesia to English.

The sensory profile was determined using projective mapping with 20 naive panelists who evaluated the aroma, flavor, acidity, body, and aftertaste and indicated their overall preference. Eight organic commercial coffees were prepared and were identified by random numbers. The samples included *Kopinata* Organic Coffee Robusta *Toraja* (429), Salu Sopai Toraja coffee (361), HiBO Organic Coffee Dark French Lembah Baliem Papua (596), HiBO Organic Coffee Black Italian Lembah Baliem Papua (781), Organic Tjap Djaran Wild Luwak coffee Lereng Gunung Arjuna (832), Organic Tjap Djaran Arabica coffee Lereng Gunung Arjuna (528), Organic Tjap Djaran Robusta coffee Lereng Gunung Arjuna (379), and Kopi Organic Tjap Djaran coffee Lanang Lereng Gunung Arjuna (926). The distribution of origin of the samples is shown in Figure 1.

The testing kit sent to the panelists included a 60 x 60 cm tablecloth for preference mapping and eight samples of single-origin organic coffee. Each sample was prepared for 2.75 g of coffee per 50 mL water. Coffee was served at a temperature of 93 °C and in a ratio of 55 g per 1000 mL water (Specialty Coffee Association of America, 2015).

2.2 Preference mapping

Preference mapping (Napping®) is a method in which panelists place a sample on a tablecloth according to the similarity or dissimilarity of sample attributes (Risvik et al., 1994; Hopfer & Heymann, 2013). The sample's placement is represented by X and Y coordinates which can be transformed into Euclidean distances (Dehlholm et al., 2012). The aim of preference mapping is to group or cluster sample characteristics based on the panel's responses; this data can be used as reference information for market segmentation (Reinbach et al., 2014). The initial step of testing is that the entire sample is provided in front of the panelists. The sample is given consists of five samples with three different digit codes. Then the 60 × 60 cm cardboard paper was given to the panelists as a base to position the sample on it. The arrangement is based on grouping the samples according to the similarity level of the sensory attributes. Similar samples are placed close together and different samples are placed far apart.

2.3 Statistical analysis

All data are reported as means and standard deviations. The preference mapping was analyzed using multiple factor analysis (MFA) with software R v.3.6.0. The MFA generates two figures simultaneously, the factor map and preference mapping. The description of the attributes was captured by using sensory wheel performed by XLSTAT Sensory v. 2021.3.1.

3 Results and discussion

3.1 Dominant attributes

The twenty panelists have categorized of the sample attributes as shown in Figure 2. Samples 926 and 361, in the upper-right

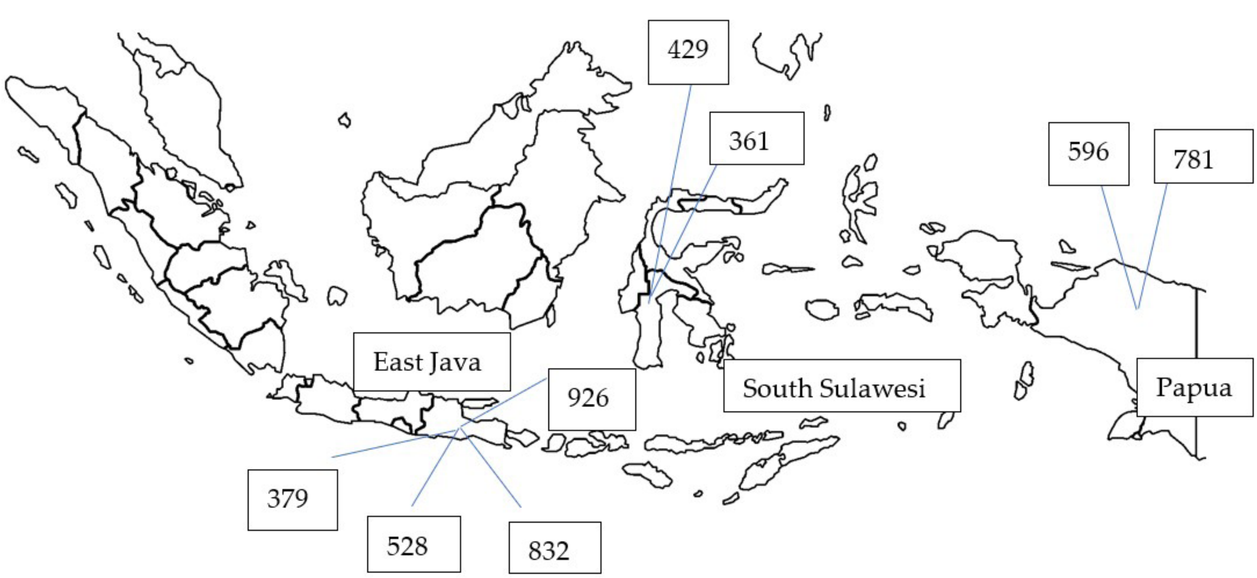

Figure 1. Distribution of the sample of single-origin organic coffee.

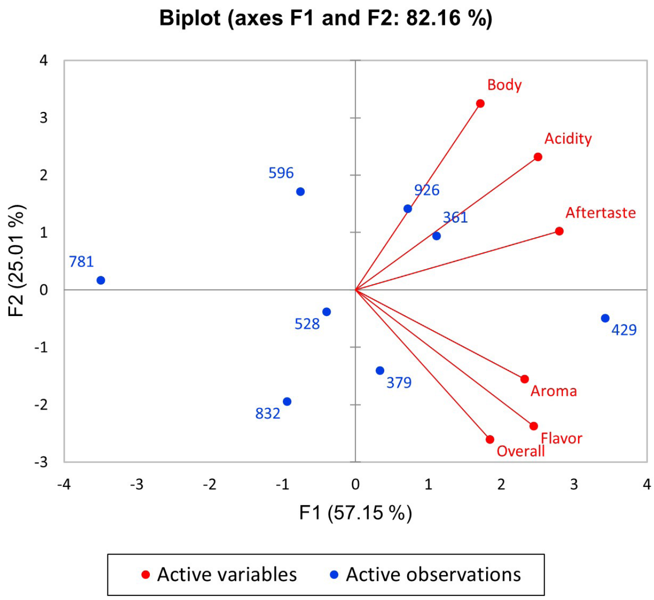

Figure 2. Biplot correlation of dominant attribute by sample.

quadrant, had dominant attributes of body, acidity and aftertaste. Samples 528 and 832, in the lower-left quadrant, had lower intensity of body, acidity, and aftertaste. Samples 379 and 429, in the lower-right quadrant, had dominant attributes of aroma and flavor as well as overall preference. Finally, samples 781 and 596, in the upper-left quadrant, were characterized as having weak in aroma and flavor.

3.2 Specific attributes

Each of the eight samples was characterized as having a unique dominant attribute, particularly in aroma and flavor. For instance, the sample from South Sulawesi was described as sweet, fruity, and floral, while the aroma of the sample from Papua was described as chocolate and sweet. The sensory wheel in Coffee was published in 1995. In 2016, this valuable resource was updated in collaboration with World Coffee Research (WCR). The foundation of this work, the World Coffee Research Sensory Lexicon, is the product of dozens of professional sensory panelists, scientists, coffee buyers, and roasting companies collaborating via WCR and SCA [The Coffee Taster's Flavor Wheel by the SCA and WCR (©2016-2020)]. This study using the similar principles that allows describe the dominant detectable attribute of all samples. Sensory wheels of the samples are depicted in Figures 3-6. The challenges in creating of this sensory wheel was the process of translation and grouping according to the most relevant translation.

The nutty aroma shown in Figures 3-6 can correspond to the presence of the *N*-heterocyclic carbene 2-acetylpyrrole (Agresti et al., 2008) or a group of pyrazines (Caporaso et al., 2018; Zakidou et al., 2021). The flavor of sour or lime is normally categorized in the citrus group. This lime or sour flavor may correspond to the presence of monoterpenes such as limonene (Kalschne et al., 2018; Zakidou et al., 2021).

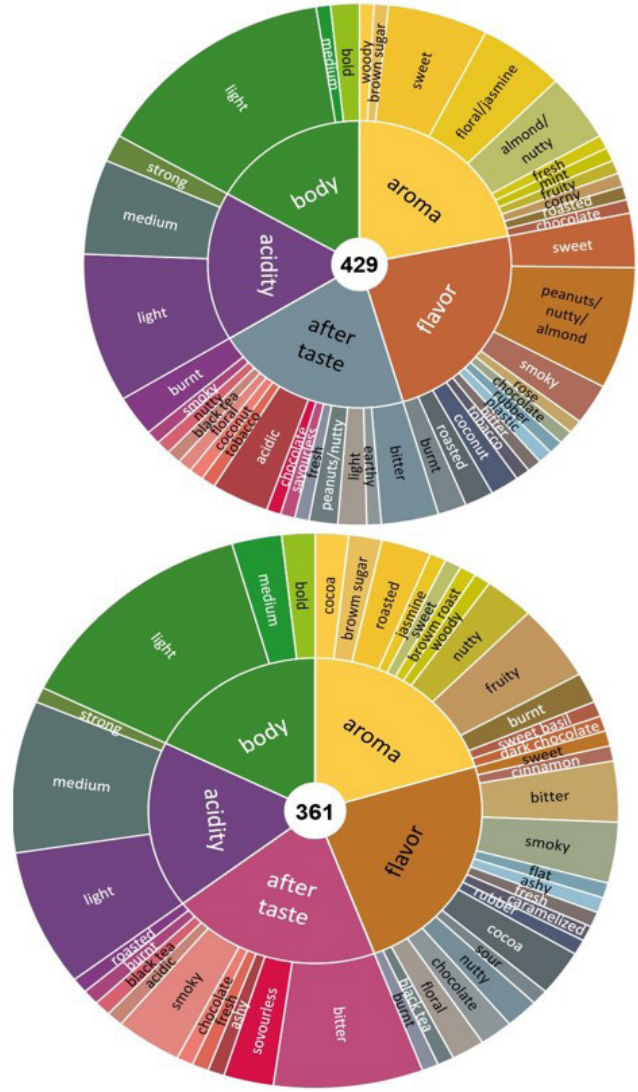

Figure 3. Sensory wheels of samples 429 and 361 (samples from Toraja-Sulawesi).

Besides caffeine that is always found in coffee by various extraction methods (Chavez et al., 2022; Mostafa, 2022), trigonelline, the *N*-methylpyridinium-3-carboxylate, is also found in higher levels in Arabica coffee compared to Robusta (Sunarharum et al., 2014). According to Oestreich-Janzen (2010), trigonelline plays an important role in coffee's aroma. The important component contributing to the flavor and aroma is the chlorogenic acid. This component contributes to the astringency and bitterness of the coffee (Ginz & Engelhardt, 2001).

3.3 Preference mapping (Napping®)

The preference mapping (Napping®) creates a factor map, hierarchical clustering, factor mapping on hierarchical clustering and preference mapping. The preference mapping allows the panelist to express the perceived sensory characteristic of her or his own terms (Jaimes & Torres, 2016). Since in the preference mapping based on the hedonic scale, discriminant test as well as descriptive test, in this scenario, panelist description is useful for initial definition the best characteristic of the product (Mielby et al., 2014).

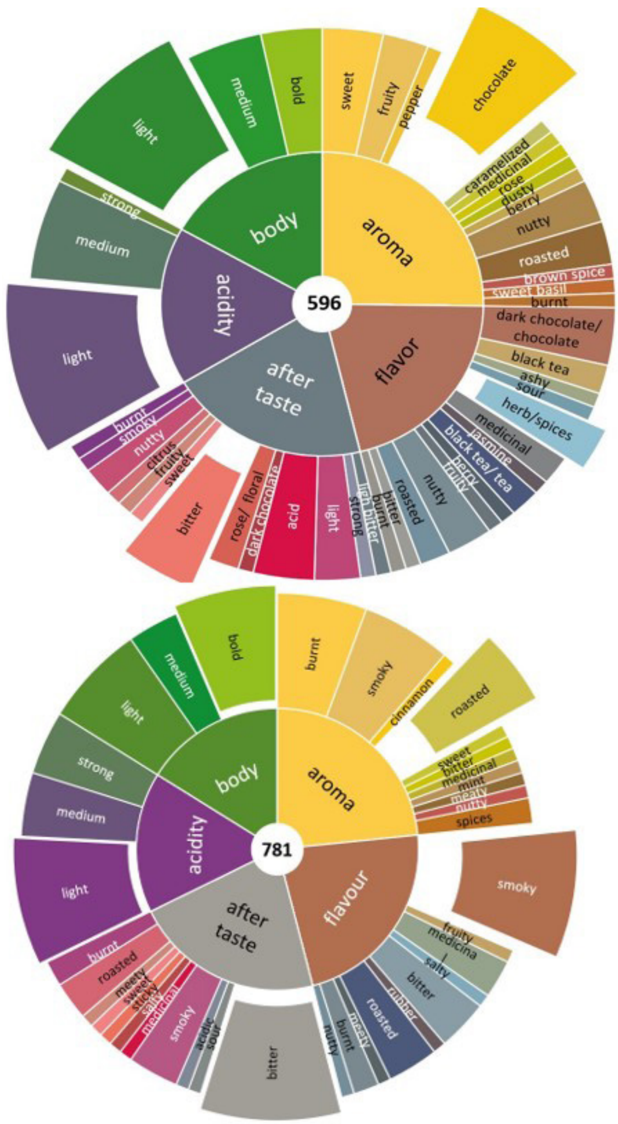

Figure 4. Sensory wheels of samples 596 and 781 (samples from Papua).

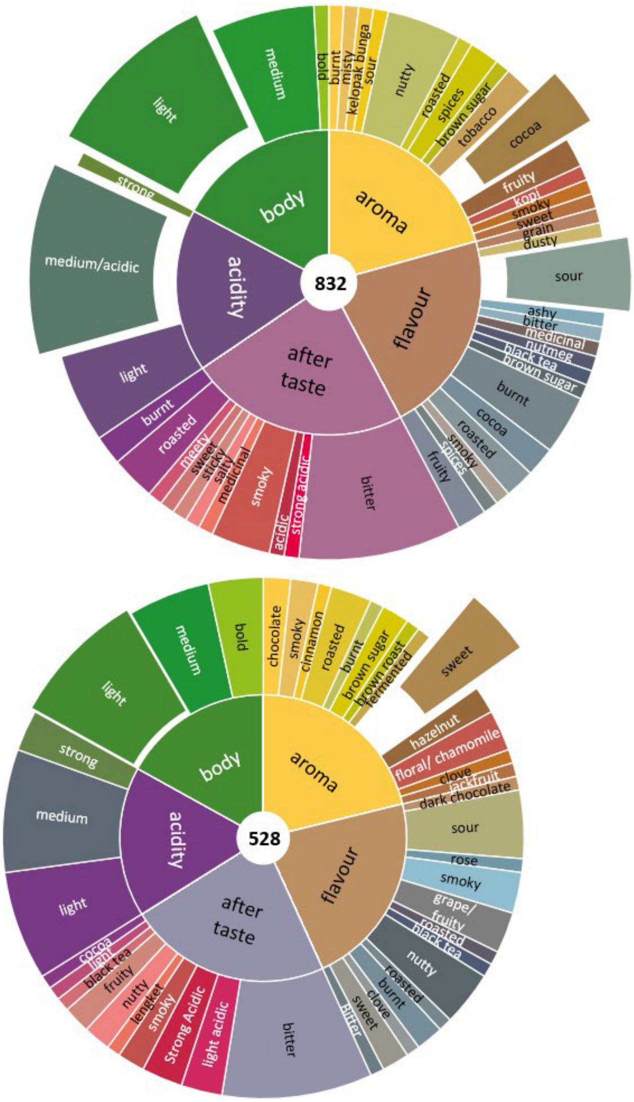

Figure 5. Sensory wheels of samples 832 and 528 (samples from East Java).

Figure 6. Sensory wheels of samples 379 and 926 (samples from East Java).

The factor map and hierarchical clustering show that the eight samples were categorized into four classes, as shown in Figure 7. The hierarchical clustering allows classification of the samples according to their similarity in degree of preference (Lê & Worch, 2015). A hierarchical clustering map was calculated based on the distance between the samples. The samples with a close distance were grouped as the same cluster. Figure 7 showed that there were four clusters.

The first cluster consisted of samples 429; this sample were derived from South Sulawesi. The second cluster consisted of samples 926 and 781; both samples were derived from East Java and Papua. The third cluster consisted of samples 361 and 832; both sampled were derived from South Sulawesi and East Java. The fourth cluster consisted of samples 596, 528 and 379; these samples were derived from Papua and East Java.

This study shows that while different samples may have distinct characteristics, they can have similar degrees of preference. For instance, the analysis shows that sample 361, from South Sulawesi, was identified as similar to sample 832, from East Java, even though the dominant characteristics seemed to be different. The similarity could be suspected from the degree of preference; although these two samples were in different quadrants, Figure 8 shows they were similar in degree of preference. The degree of preference can be identified by the different color contours shown in Figure 8. Degree values indicate level of preference by the panelists, with higher degree values corresponding to higher preference. These two samples both lie near 20 degrees, indicating a similar and low degree of preference. Thus, while according to the factor map the two samples had different characteristics, they had equal degrees of preference according to the preference mapping.

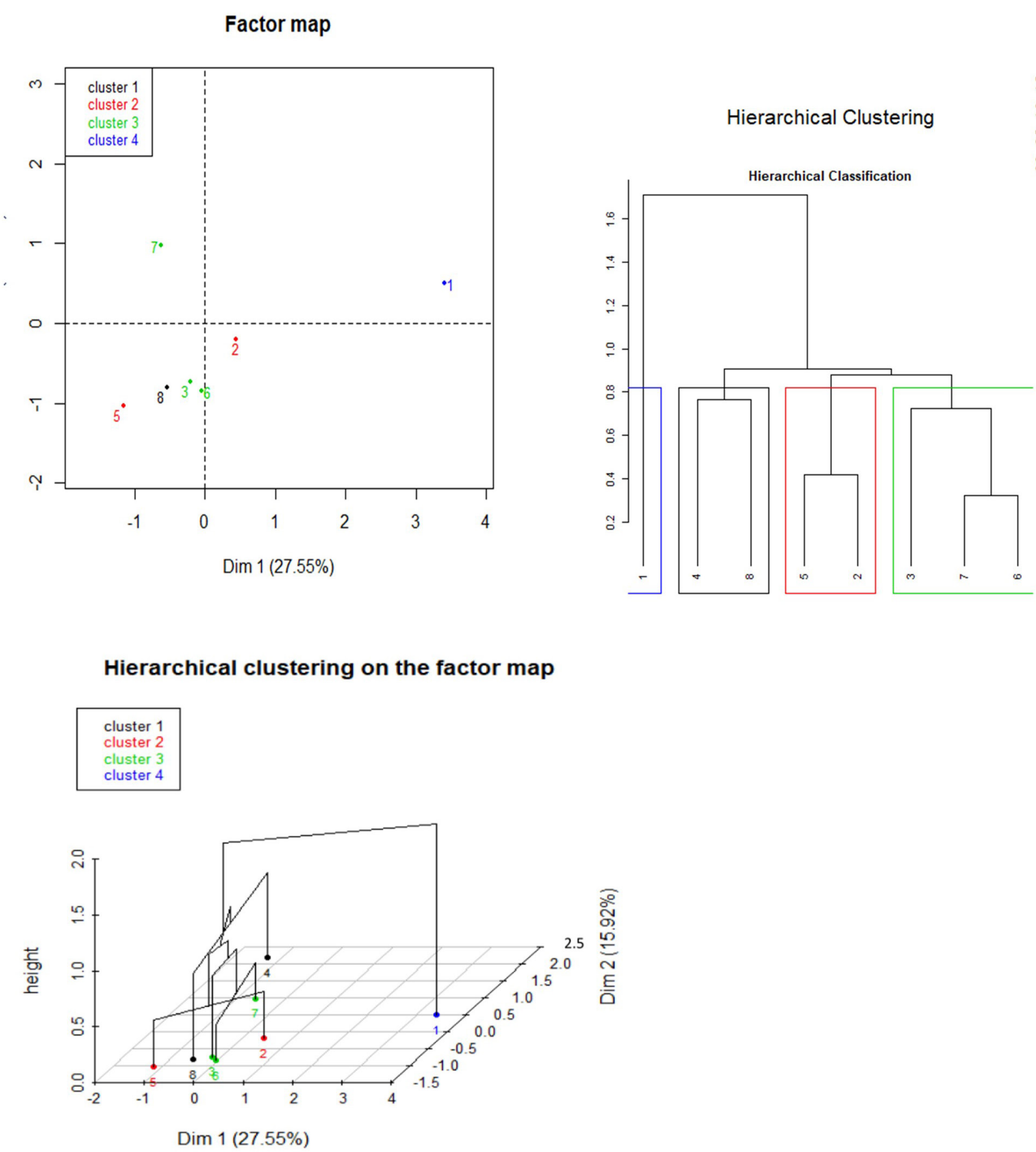

Figure 7. Factor map and hierarchical clustering: 1 (429), 2 (361), 3 (596), 4 (781), 5 (832), 6 (528), 7 (379), 8 (926).

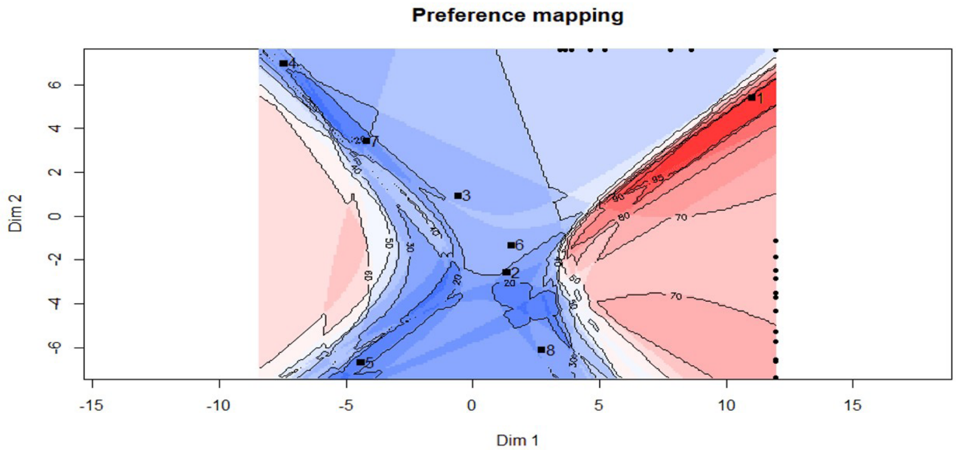

Figure 8. Preference mapping of single-origin organic coffee: 1 (429), 2 (361), 3 (596), 4 (781), 5 (832), 6 (528), 7 (379), 8 (926).

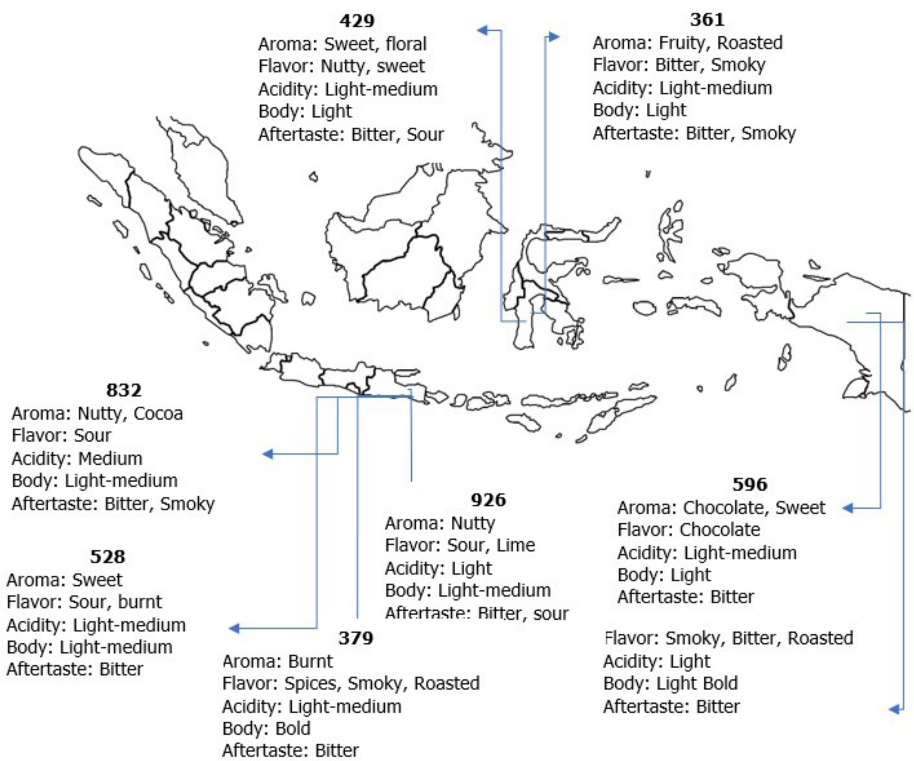

Figure 9. Distribution of the eight samples and their dominant attributes.

Enhancing knowledge of consumer preference, we continue to analyze preference mapping as can be shown in Figure 8. The overall liking of the samples and sensory experience has important factor that contribute the consumers buying discission. The sample 429 was the most preferred, as indicated by its location in Figure 8 in the upper-right quadrant and near the 90^0 contour line. While the degree value represents the panels' preference level for each sample, the quadrant represents the similarities of the characteristic of the samples. For instance, samples 781 and 379 lie in the same quadrant, indicating they had similar characteristics, but these two samples had different degrees of preference. As Figure 8 shows, sample 379 lies near the 20^0 contour line and sample 781 lies near the 40^0 contour line. Furthermore, Figure 8 explained, the sample 1 (429) are categorized as most preferred (there for highlighted in deep read). In contrast to that 5 (832), 7 (379) and 2 (361) achieved the most negative perception. One of the reason sample 1 (429) is the most preference probably because of this product is familiars among consumers.

4 Conclusion

Using preference mapping, sensory wheels, and hierarchical clustering, this study found that the eight samples of single-origin organic coffee had different dominant attributes, as illustrated in Figure 9. This description would be benefit for clustering the consumer segmentation or perhaps the traceability of factors create the dominant attributes. Further research may identify the relationship of the aroma and flavor to location characteristics such as humidity, soil, or the variety of the coffee. The most preferable is the sample 429 (*Kopinata* Organic Coffee Robusta *Toraja*) compared to other samples.

Acknowledgements

This work was funded by Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia, WCR Grant [grant number SP DIPA- 023.17.1.690439/2021].

References

Agresti, P. D. C. M., Franca, A. S., Oliveira, L. S., & Augusti, R. (2008). Discrimination between defective and non-defective Brazilian coffee beans by their volatile profile. *Food Chemistry*, 106(2), 787-796. http://dx.doi.org/10.1016/j.foodchem.2007.06.019.

Bressani, A. P. P., Martinez, S. J., Batista, N. N., Simão, J. B. P., & Schwan, R. F. (2021). Into the minds of coffee consumers: perception, preference, and impact of information in the sensory analysis of specialty coffee. *Food Science and Technology*, 41(Suppl. 2), 667-675. http://dx.doi.org/10.1590/fst.30720.

Caporaso, N., Whitworth, M. B., Cui, C., & Fisk, I. D. (2018). Variability of single bean coffee volatile compounds of Arabica and robusta roasted coffees analysed by SPME-GC-MS. *Food Research International*, 108, 628-640. http://dx.doi.org/10.1016/j.foodres.2018.03.077. PMid:29735099.

Chavez, S. G., Mendoza, M. M., & Caetano, A. C. (2022). Antioxidants, phenols, caffeine content and volatile compounds in coffee beverages obtained by different methods. *Food Science and Technology*, 42, e47022. http://dx.doi.org/10.1590/fst.47022.

Dehlholm, C., Brockhoff, P. B., Meinert, L., Aaslyng, M. D., & Bredie, W. L. P. (2012). Rapid descriptive sensory methods – comparison of free multiple sorting, partial Napping, Napping, flash profiling and conventional profiling. *Food Quality and Preference*, 26(2), 267-277. http://dx.doi.org/10.1016/j.foodqual.2012.02.012.

Doepker, C., Movva, N., Cohen, S. S., & Wikoff, D. S. (2022). Benefit-risk of coffee consumption and all-cause mortality: a systematic review and disability adjusted life year analysis. *Food and Chemical Toxicology*, 170, 113472. http://dx.doi.org/10.1016/j.fct.2022.113472. PMid:36243217.

Fernqvist, F., & Ekelund, L. (2014). Credence and the effect on consumer liking of food – a review. *Food Quality and Preference*, 32, 340-353. http://dx.doi.org/10.1016/j.foodqual.2013.10.005.

Gemechu, F. G. (2020). Embracing nutritional qualities, biological activities and technological properties of coffee byproducts in functional food formulation. *Trends in Food Science & Technology*, 104, 235-261. http://dx.doi.org/10.1016/j.tifs.2020.08.005.

Ginz, M., & Engelhardt, U. (2001). Identification of new diketopiperazines in roasted coffee. *European Food Research and Technology*, 213(1), 8-11. http://dx.doi.org/10.1007/s002170100322.

GMD Research. (2021). *Global organic coffee market 2020-2030 by origin (Arabica, Robusta), coffee type (fair trade, gourmet, espresso, coffee pods), roast (light, medium, dark), packaging type, end user, distribution channel, and region: trend forecast and growth opportunity*. Chicago: GMD Research. Retrieved from https://www.reportocean.com/industry-verticals/details?report_id=GMD633

Hopfer, H., & Heymann, H. (2013). A summary of preference mapping observations–the effect of replicates and shape, and individual performance measurements. *Food Quality and Preference*, 28(1), 164-181. http://dx.doi.org/10.1016/j.foodqual.2012.08.017.

International Coffee Organization – ICO. (2021). *World coffee consumption*. Retrieved from http://www.ico.org/prices/new-consumption-table.pdf

International Organization for Standardization – ISO. (2003). *ISO 13299:2003: sensory analysis — methodology — general guidance for establishing a sensory profile*. Geneva: ISO.

International Organization for Standardization – ISO. (2014). *ISO 111362014: sensory analysis — methodology — general guidance for conducting hedonic tests with consumers in a controlled area*. Geneva: ISO.

Jaimes, E. M. S., & Torres, I. B. (2016). Sensory analysis on the evaluation of commercial coffee brands; an application of projective maps. *DYNA Management*, 4, 1-13. http://dx.doi.org/10.6036/MN8086.

Kalschne, D. L., Viegas, M. C., Conti, A. J., Corso, M. P., & Benassi, M. T. (2018). Steam pressure treatment of defective *Coffea canephora* beans improves the volatile profile and sensory acceptance of roasted coffee blends. *Food Research International*, 105, 393-402. http://dx.doi.org/10.1016/j.foodres.2017.11.017. PMid:29433228.

Kamiloglu, S. (2019). Authenticity and traceability in beverages. *Food Chemistry*, 277, 12-24. http://dx.doi.org/10.1016/j.foodchem.2018.10.091. PMid:30502127.

Król, K., Gantner, M., Tatarak, A., & Hallmann, E. (2020). The content of polyphenols in coffee beans as roasting, origin and storage effect. *European Food Research and Technology*, 246(1), 33-39. http://dx.doi.org/10.1007/s00217-019-03388-9.

Lê, S., & Worch, T. (2015). *The R series: analyzing sensory data with R*. New York: CRC Press.

Mercanta. (2021). *Traceability: what is it and why is it important?* Retrieved from https://www.coffeehunter.com/the-journal/traceability-what-is-it-and-why-is-it-important/

Mielby, L. H., Hopfer, H., Jensen, S., Thybo, A. K., & Heymann, H. (2014). Comparison of descriptive analysis, projective mapping and sorting performed on pictures of fruit and vegetable mixes. *Food Quality and Preference*, 35, 86-94. http://dx.doi.org/10.1016/j.foodqual.2014.02.006.

Mostafa, H. S. (2022). Assessment of the caffeine-containing beverages available in the local markets, and development of a real energy drink based on the date fruit. *Food Science and Technology*, 42, e51820. http://dx.doi.org/10.1590/fst.51820.

Oestreich-Janzen, S. (2010). Chemistry of coffee. In B. L. Hung-Wen & L. Mander. (Eds.), *Comprehensive natural products II: chemistry and biology* (pp. 1085-1117). Amsterdam: Elsevier. http://dx.doi.org/10.1016/B978-008045382-8.00708-5.

Persaud, K. C., Lee, D.-H., & Byun, H.-G. (1999). Objective odour measurements. In A. Jain, R. Bolle & S. Pankanti (Eds.), *Biometrics: personal identification in networked society* (pp. 251-272. New York: Kluwer Academic Publishers. http://dx.doi.org/10.1007/0-306-47044-6_12.

Reinbach, H. C., Giacalone, D., Ribeiro, L. M., Bredie, W. L. P., & Frøst, M. B. (2014). Comparison of three sensory profiling methods based on consumer perception: CATA, CATA with intensity and Napping. *Food Quality and Preference*, 32, 160-166. http://dx.doi.org/10.1016/j.foodqual.2013.02.004.

Risvik, E., McEwan, J. A., Colwill, J. S., Rogers, R., & Lyon, D. H. (1994). Projective mapping: a tool for sensory analysis and consumer research. *Food Quality and Preference*, 5(4), 263-269. http://dx.doi.org/10.1016/0950-3293(94)90051-5.

Schouteten, J. J., Gellynck, X., & Slabbinck, H. (2019). Influence of organic labels on consumer's flavor perception and emotional profiling: comparison between a central location test and home-use-test. *Food Research International*, 116, 1000-1009. http://dx.doi.org/10.1016/j.foodres.2018.09.038. PMid:30716882.

Skeie, T. R. (2003). *Norway and coffee. The Flamekeeper, newsletter of the Roaster Guild*. Retrieved from https://web.archive.org/web/20031011091223/http:/roastersguild.org/052003_norway.shtml

Specialty Coffee Association of America – SCAA. (2015). *SCAA protocols. Cupping specialty coffee*. Irvine: SCAA. Retrieved from https://www.scaa.org/PDF/resources/cupping-protocols.pdf

Sunarharum, W. B., Williams, D. J., & Smyth, H. E. (2014). Complexity of coffee flavour: a compositional and sensory perspective. *Food Research International*, 62, 315-325. http://dx.doi.org/10.1016/j.foodres.2014.02.030.

Vitzthum, O. G. (1999). Thirty years of coffee chemistry research. In R. Teranishi, E. L. Wick & I. Hornstein (Eds.), *Flavour chemistry: thirty years of progress* (pp. 117-133). New York: Kluwer Academic Publishers. http://dx.doi.org/10.1007/978-1-4615-4693-1_11.

Zakidou, P., Plati, F., Matsakidou, A., Varka, E.-M., Blekas, G., & Paraskevopoulou, A. (2021). Single origin coffee aroma: from optimized flavor protocols and coffee customization to instrumental volatile characterization and chemometrics. *Molecules*, 26(15), 4609. http://dx.doi.org/10.3390/molecules26154609. PMid:34361765.