Effect of genotype and storage duration on taste and ecovalence of roasted beans of Arabica coffee (Coffea arabica L.)

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Abstract. Coffee genotype that performs delicious taste for long time is an ideal coffee genotype that has to be created. Several researches reported that taste of roasted bean and ground coffee decreased along with duration of storage. However, no research reports revealed information about stability of taste of coffee. The goal of this research was to determine stability of taste. Twenty eight genotypes of Arabica coffee growing in North Sumatra Province of Indonesia were stored in sealed aluminium foil packs on storage duration of 0, 6, 12, and 18 months at room temperature. The research was carried out with randomized complete block design with three replications. The stability of taste was calculated by using Wricke’s ecovalence. The result revealed a highly significant differences in taste between genotypes as well as between storage duration. No interaction between genotype and storage duration. Based on the ecovalence, the genotypes could be grouped into 4 clusters. The initial taste score of genotypes at 0 month of storage duration had highly significant correlation with ecovalence of genotypes (r = 0.615**). The higher the initial taste score was, the less stability of the taste was. Genotype Sm16 had the most stable taste over storage duration. It can be concluded that storage duration of roasted bean of Arabica coffee must be less than 6 month. Selection on highest taste score would be the best way to maintain highest taste score after certain storage period even this genotype could have the lowest tability of taste. The date of roasting of coffee sold to public must be written on the pack.

1. Introduction
Stability of taste of coffee is very important due to storage of green bean, roasted beans, and ground coffee. Effect of storage periods of green beans of nine genotypes of Arabica coffee on taste was researched by [1]. It revealed that green beans stored for 1-2 years performed a change in taste. Taste of green beans stored for 2 years was lower than stored for 1 year and 0 year. Five genotypes experienced lower change in flavor than others. Storage affected the physico-chemical properties of Liberica green beans [2]. Aroma of roasted beans and ground coffee could be unstable and decrease due to storage through lossing of in volatile components and chemical degradation at longer storage [3]. Aroma is one of 10 attributes of taste of coffee. Unfortunately, no research reports could be found which revealed effect of storage on taste of roasted beans and ground coffee. Storage duration influenced physical properties of Coffea canephora and Coffea Arabica [4]. Taste of Arabica coffee could be
different due to genotypes [5]. However, stability of taste of coffee genotypes were not yet known. The objective of this research was to determine taste stability of genotypes of Arabica coffee.

2. Materials and method

2.1. Data collection

Roasted beans of 28 genotypes of Arabica coffee were put in sealed aluminum foil packs and then stored for 0, 6, 12, and 18 months in a glass cabinet at room temperature. To prevent exposure to air that could affect the chemical content of roasted beans during storage [6], the packs were sealed. Initial taste score was collected at 0 month of storage duration. Taste was determined by following the cupping method of the Specialty Coffee Association of America [7]. Taste score (maximum 100) was the sum of scores of all taste attributes. The taste attributes were flavor, fragrance/aroma, sweetness, aftertaste, body, acidity, uniformity, clean cup, balance, overall, and defect. The taste test was carried out by a panel of taste testers. They were Licensed Q Grader and experienced taste testers. The taste test was conducted in the cupping laboratory of Goldenways Coffee Company in Medan. The experiment was conducted from December 2012 to June 2014.

2.2. Data analysis

A factorial experiment was conducted by using randomized complete block design and three replications [8]. The linear additive mathematical model was $y_{ijk} = \mu + \rho_i + \beta_j + (\rho\beta)_{ij} + \kappa_k + \varepsilon_{ijk}$ where $y$, $\mu$, $\rho$, $\beta$, $\rho\beta$, $\kappa$, and $\varepsilon$ were observation value, mean, effect of genotype, effect of storage duration, effect of interaction of genotype and storage duration, effect of block, and experimental error, respectively. On analysis of variance, the significance of each source of variations was tested by comparing its calculated F value to tabular F value. Comparison between treatment means was carried out by using Fisher’s least significant difference at $\alpha = 0.05$. Analysis of simple correlation was also conducted. Wricke’s ecovalence was used as stability measure for genotype [9]. Eccovalence ($W^2_i$) of each genotype was calculated by the formula $W^2_i = \Sigma (a_{ij} - \bar{a}_i - \bar{a}_j + \bar{a})^2$ where $a_{ij}$, $\bar{a}_i$, $\bar{a}_j$, and $\bar{a}$ were taste score of genotype $i$ in storage duration $j$, means of genotype $i$, means of storage duration $j$, and grand means of taste score, respectively. Genotype having the smallest ecosvalence was the most stable. The hierarchical cluster analysis using between-group linkage method with squared Euclidean distance was conducted whereby genotype was treated as operational taxonomic unit while initial taste score and ecovalence were used as variables. Microsoft Excel Version 2007 and IBM SPSS Version 19 were used for analysis of data.

3. Results and discussion

Genotypes and storage duration were highly significantly different (Table 1). However, no interaction between genotypes and storage duration was found. Genotype Dr20 performed the highest taste score (Table 2). Even in 6 months of storage duration, taste score was significantly lower than initial taste score at 0 month of duration of storage.

| Source of variation | Degree of freedom | Sum of square | Mean square |
|---------------------|-------------------|---------------|-------------|
| Block               | 2                 | 56,22         | 28,11 ns    |
| Treatment           | 111               | 11034,46      | 99,41 **    |
| Genotype (G)        | 27                | 1698,77       | 62,92 **    |
| Storage duration (D)| 3                 | 8411,58       | 2803,86 **  |
| GxD                 | 81                | 924,10        | 11,41 ns    |
| Error               | 222               | 2124,58       | 9,57        |
| Total               | 335               | 13215,25      |             |
IOP Conf. Series: Materials Science and Engineering 508 (2019) 012115 doi:10.1088/1757-899X/508/1/012115

The cluster method provides information about the similarity of one genotype to another in the genotypes could be clustered in five different groups (Figure 3). Because taste score of genotype Dr20 was not significantly different at α = 0.05 and α = 0.01, respectively. The means having the same common letter in the same row or column were not significantly different at α = 0.05.

Storage duration (x) and taste score over genotypes (y) negatively significantly correlated with correlation coefficient $r = -0.994^{**}$ and equation $y = 85.20 - 0.74x$ (Figure 1). It means, taste of coffee will decrease significantly in line with the increase in storage time. The decrease in taste is in line with research result by [10]. The taste decrease could be caused by chemical degradation [3].

Ecovalence ranged from 1.33 to 51.52 (Table 2). Genotype So16 had the most stable taste while genotype Dr19 performed the most unstable taste.

The initial taste score of genotypes i.e. taste score at 0 month of storage duration (x) had highly significant positive correlation with ecovalence of genotypes (y) with coefficient correlation $r = 0.615^{**}$ and equation $y = -129.67 + 1.69x$ (Figure 2). It means, genotype that performs better taste will have lower stability of taste. The higher the taste score was, the less the taste stability was.

The cluster method provides information about the similarity of one genotype to another in the parameters considered. Based on initial taste score i.e. taste score at 0 month of storage duration, genotypes could be clustered in five different groups (Figure 3). Because taste score of genotype Dr20 was not significantly different at α = 0.05 and α = 0.01, respectively. The means having the same common letter in the same row or column were not significantly different at α = 0.05.

**Table 2.** Taste score and ecovalence of roasted beans of Arabica coffee.

| Number | Genotype | Storage duration (months) | Avgareage of taste score | Ecovalence $W^2$ |
|--------|----------|--------------------------|--------------------------|-----------------|
|        |          | 0 | 6 | 12 | 18 |                          |                |
|        | Taste score | Taste score | Taste score | Taste score |                           |                |
| 1      | Hh1      | 90.40 | 86.53 | 74.93 | 71.73 | 80.90 ef | 38.48            |
| 2      | Hu2      | 90.30 | 86.93 | 79.40 | 72.03 | 82.17 bc | 17.41            |
| 3      | Hm3      | 82.30 | 82.13 | 77.77 | 70.73 | 78.23 j-n | 7.34             |
| 4      | Hb4      | 90.80 | 82.70 | 81.40 | 76.40 | 82.83 b | 14.60            |
| 5      | Ss5      | 80.80 | 78.73 | 76.73 | 69.83 | 76.53 t-x | 9.06             |
| 6      | Si6      | 82.03 | 83.70 | 76.17 | 70.77 | 78.17 j-o | 11.02            |
| 7      | Sm7      | 81.67 | 83.07 | 76.70 | 69.73 | 77.79 m-r | 11.60            |
| 8      | Sa8      | 83.43 | 80.77 | 78.33 | 71.87 | 78.60 j-l | 5.52             |
| 9      | Pp9      | 80.00 | 78.30 | 74.03 | 66.83 | 74.79 a | 3.42             |
| 10     | Pa10     | 82.70 | 82.37 | 75.83 | 69.30 | 75.55 m-s | 5.49             |
| 11     | Pk11     | 82.57 | 82.53 | 75.83 | 72.07 | 78.25 j-m | 5.36             |
| 12     | Pp12     | 82.07 | 82.47 | 75.17 | 67.07 | 76.69 t-w | 14.83            |
| 13     | Ss13     | 81.93 | 82.40 | 76.50 | 70.53 | 77.84 t-q | 6.65             |
| 14     | Sa14     | 82.90 | 84.67 | 74.83 | 72.63 | 78.76 i-j | 16.11            |
| 15     | Sm15     | 84.07 | 82.23 | 75.20 | 70.73 | 78.06 t-p | 2.00             |
| 16     | So16     | 84.60 | 82.97 | 77.97 | 72.53 | 79.52 h-i | 1.33             |
| 17     | Dd17     | 91.07 | 84.10 | 77.93 | 74.83 | 81.98 e-d | 14.14            |
| 18     | Da18     | 92.57 | 83.27 | 77.60 | 71.13 | 81.14 e | 40.88            |
| 19     | Dr19     | 92.50 | 81.60 | 76.30 | 70.67 | 80.27 t-h | 51.52            |
| 20     | Dr20     | 93.03 | 84.80 | 79.60 | 77.03 | 82.62 a | 18.95            |
| 21     | Tt21     | 86.07 | 83.17 | 77.63 | 74.80 | 80.42 e-g | 2.80             |
| 22     | Ta22     | 83.00 | 78.20 | 75.60 | 72.33 | 77.28 p-t | 9.16             |
| 23     | Tp23     | 84.33 | 82.83 | 75.87 | 71.53 | 78.64 t-k | 1.95             |
| 24     | Ta24     | 81.00 | 78.73 | 76.40 | 70.80 | 76.73 t-v | 8.43             |
| 25     | Tt25     | 81.43 | 76.20 | 73.37 | 72.13 | 75.78 x-y | 18.71            |
| 26     | To26     | 79.37 | 77.73 | 75.40 | 70.17 | 75.67 y-z | 12.01            |
| 27     | Tb27     | 79.17 | 74.83 | 72.73 | 70.10 | 74.21 a-j | 15.98            |
| 28     | Ta28     | 82.50 | 76.93 | 76.77 | 72.03 | 77.06 q-u | 17.60            |

Least significant difference (LSD) value between taste score over genotypes is 0.10 and 0.14 at α = 0.05 and α = 0.01, respectively. The means having the same common letter in the same row or column were not significantly different at α = 0.05.
was similar with taste score Da18 and Di19, these three genotypes were clustered into the same group (Cluster 2-a). It indicated the same highest score of taste was performed by genotype Dr20, Da18 and Di19.

Genotypes were clustered into four groups based on ecovalence (Figure 4). Genotypes Hh1 had similar ecovalence with Da18. It seemed genotypes in the same cluster based on taste score (Figure 3) might not be in the same cluster based on ecovalence (Figure 4). However, since ecovalence had highly significant correlation with initial taste score (Figure 2), genotype clustering could also be carried out based on both ecovalence and initial taste score. The result of this clustering revealed that genotypes were clustered in five groups (Figure 5). It indicated genotypes Hh1 were similar with Da18 by considering both taste score and ecovalence. In the future, researches might be needed to investigate whether stability of taste of genotype could be transmitted to progeny. Because taste had low heritability [11], taste stability might have also low heritability. Besides, it would also be important to be researched whether selection on taste stability could be carried out indirectly on the basis of the coffee morphology [12] as well as to what extent climate could influence taste stability [13].

![Figure 1](image1.png)

Figure 1. Correlation between storage duration (x) and taste score over genotypes (y).

![Figure 2](image2.png)

Figure 2. Correlation of taste score at 0 month of storage duration (x) with ecovalence (y).
Figure 3. Clustering of 28 genotypes based on taste score at 0 months of storage duration.

Figure 4. Clustering of 28 genotypes based on ecovalence.

Figure 5. Clustering of 28 genotypes of Arabica coffee based on taste score at 0 month of storage duration and ecovalence.
4. Conclusion
This research revealed that genotypes were different in taste stability measured by ecovalence. In plant breeding strategy, the genotype performing highest taste score would be better selected for gaining high taste score after storage. On the packaging of coffee that is traded, it should be stated the date of roasting.

Acknowledgment
The authors are thankful to Goldenways Coffee Company for funding this research.

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