Sensory Profiling of Two Commercial Ground-Roasted Arabica Filter Coffees Presented with and without Sweetener and Milk

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Abstract

The aim of this study was to evaluate the descriptive sensory attributes of coffee presented to trained assessors in four different ways (black unsweetened, black sweetened, white unsweetened and white sweetened), and also to obtain information on untrained assessor hedonic preferences for the same four different presentation styles. Sensory profiles of two commercial ground-roasted Arabica coffees (currently available on the Irish and UK marketplace) were studied through Sensory Acceptance Testing (n = 24) and Ranking Descriptive Analysis (n = 20). ANOVA-Partial Least Square Regression (APLSR) was used to analyse the experimental data. This study established that the naïve assessors preferred both coffee samples when served white unsweetened and white sweetened. In terms of the descriptive attributes, it is evident that when coffee is served black, the attributes are more pronounced.

Keywords

Sensory Profiles, Coffees, Attributes

1. Practical Application

The results of this study will provide researchers with information on how they should present samples in development studies. It will also provide information to coffee companies and people interested in the area of marketing and coffee as it provides information on assessor coffee habits and preferences and an insight into how various coffee attributes are affected by adding sweetener and/milk to


2. Introduction

Coffee is one of the world’s most popular beverages, owing to its distinctive aroma and flavour. Coffee is grown worldwide in more than 50 countries. The majority of these countries are developing countries [1]. World coffee consumption is growing each year. The global consumption of coffee has shown an average increase of 2.5% per year since 2011 [2]. Even with coffee consumption increasing each year there is little information available about assessor coffee choice and preference in terms of coffee consumption habits. Coffee drinkers have different coffee consuming and taste preference and like to imbibe coffee in different ways (i.e. black, with milk/creamer, sweetened etc.). For example, it is common practice to add creamer to a coffee beverage in the United States, and in Brazil assessors generally add whole milk, skimmed milk or semi-skimmed milk to their coffee beverage prior to consumption [3]. A survey conducted by the Irish Coffee Council and Amárach Research [4] on 1000 Irish assessors reported that three quarters of Irish adults drink coffee and that 87% of coffee drinkers added something to their beverage, with 70% of 15 - 24 year olds adding milk and 47% of 15 - 24 year olds adding sugar and 8% adding cream. Thus, assessors have developed a hedonic preference for how they like their coffee. In this present study, by presenting coffee in four different presentation styles (black unsweetened, black sweetened, white unsweetened and white sweetened) and asking assessors to rank the coffees against one another it allows the complete descriptive nature of the coffee to be explored.

Generally, assessors add milk/creamers to coffee beverages to increase the body of the coffee and to reduce sourness, bitterness and astringency of the coffee beverage [5]. Previous studies have also reported that gender has a large influence on coffee presentation style [6] [7]. Narian et al. 2004 [7], evaluated assessor coffee drinking preference (n = 150) and examined segmentation. They also evaluated the coffee samples presented black unsweetened, white unsweetened and white sweetened using a trained panel (n = 13) but results were focused on how it affected the coffee blends.

To our knowledge, no study has evaluated how coffee presented, standardised, in four different ways (black unsweetened, black sweetened, white unsweetened and white sweetened) affects the descriptive sensory attributes of the beverages when ranking the four presentation styles amongst each other. Additionally, consumers who use milk and sugar in their hot beverages dose to their own personal tastes and thus this poses a dilemma for sample presentation and standardisation of sensory experiments. A standardised product presented black, with or without sugar or milk will likely be a departure from the assessor’s ideal way of consuming the product. Traditionally, the preferred solution was to present samples black for all, but again this is a departure for many from their regular consumption format. The presented study also looks at which presenta-
tion style untrained assessors \( n = 24 \) prefer when comparing the standardised (black unsweetened, black sweetened, white unsweetened and white sweetened) products presented to them. Thus, the aim of this present study was to investigate how assessors perceived the sensory (hedonic, descriptive) properties of two different commercial black coffees when presented black unsweetened, black sweetened, white unsweetened and white sweetened in order to obtain a greater understanding of coffee beverage composition on resulting sensory profiles.

3. Materials and Methods

3.1. Coffee Samples

Two different commercial ground-roasted coffees were selected for this trial. From previous trials carried out on a vast range of coffees available in the Republic of Ireland, the ground-roasted filter coffees that panellists’ preferred was established, consequently these were the coffee products that were used in this study [8] [9] [10]. Both coffees were made from ground roasted 100% arabica beans and had a Total Dissolved Solids reading of 0.86% and 0.81%. Coffee samples were bought from an Irish supermarket. Samples were stored at room temperature, in a cool, dry storage area until the trial commenced. All coffees were opened fresh on each trial day. The sweetener used in this trial was white sugar sachets (Brand: GEM) which were purchased from a local supermarket and stored in a cool dry place until the trial started. The whitener used in this trial was CMP fresh milk which was purchased from a local supermarket on the day of the trial and was stored in the fridge (2˚C - 5˚C).

3.2. Sample Preparation

Each coffee was prepared following the preparation protocol to ensure coffee samples were standardised throughout the trial.

The standardised preparation protocol for ground-roasted filter coffee (Cafetière):

A kettle was filled with water and boiled to 100˚C. The National Coffee Association [11] recommends the water for brewing should be in the range of 90.6˚C - 96.1˚C, thus once the temperature of the water in the kettle decreased to 95˚C (±1˚C) the cafetière was warmed by filling it with approx. 130 mL of the boiled water and swirling the water around for 10 s prior to disposing of the water. Fresh ground-roasted coffee (12.5 g) was then placed into the warmed cafetière, as International standards suggest a ratio of 5 - 9 g coffee per 100 mL of water [12]. The cafetière was filled with approx. 250 mL of the boiled water and the contents were stirred using a metal tablespoon. After a three min extraction period the cafetière plunger was pressed down on contents and 177 mL of the brewed coffee was poured into a 237 mL paper-based cups (methyl cellulose internally and externally coated with polyethylene). Milk and/or sugar were added to the samples accordingly. 15 mL of fresh milk (CMP dairy, Cork, Ireland) was added to the required samples to whiten. One sugar sachet (5 g) was added to
the required coffee samples to sweeten them. Condiments were added by the researchers carrying out the trial. Once the contents of the cup were at 70°C (±1°C) they were served to assessors. From a previous study carried out by the team 70.8°C was found to be the preferred temperature for serving black coffee thus this is why we chose to use this temperature in this study [8].

3.3. Percentage Total Dissolved Solids (% TDS)

Three readings were taken from three different samples and an average was calculated from the three samples. The method used was as follows:

An ice bath was prepared. The Refractometer (VST Inc. digital refractometer from SCAE store, Essex, UK) was calibrated using distilled water. A kettle was used to boil water to 100°C and a thermometer (model: testo 110. Tolerable margin of error ±1°C. Supplied by Testo AG, Germany) was used to monitor the temperature after boiling and once the temperature of the water reached 95°C (±1°C) the coffee was prepared following the Standardised protocol for filtered brewed coffee preparation in this paper. A plastic 10 mL syringe (BD Plastipak syringe) was used to transfer 10 mL of the brewed coffee from the paper-based cup into a ceramic cup and the ceramic cup was immediately placed on the ice bath. The temperature of the coffee in the ceramic cup was continuously monitored until it reached 22°C (±2°C). For filter coffee, a 10 mL syringe (BD Luer-Lok Tip 10 mL syringe) was used to take up 4 mL of the coffee. A syringe filter was then placed on the syringe and 2 mL of the contents of the syringe was transferred to a clean ceramic cup. Using a 1 mL plastic pipette dropper 0.3 mL of the filter coffee sample was transferred into the sample well of the refractometer. The sample cover was closed and the sample was left for 20 s in the sample well to equilibrate to the temperature of the instrument. Then the % TDS was obtained and recorded. A new filter and syringe was used for each measurement.

3.4. Sensory Acceptance Testing

Sensory acceptance testing was conducted using untrained assessors [13] [14] (n = 24) in the age range of 18 - 52. They consisted of 10 males and 14 females, were chosen on the basis that they regularly consumed coffee. In terms of occupation, three of the males were in professional jobs, five were postgraduate students and two were undergraduate students. Two of the males drank black coffee, one drank white coffee, four drank white coffee with sweetener and three drank black coffee with sweetener. Out of the females two were in professional jobs, six were postgraduate students and six were undergraduate students. Two of the females drank black coffee, several drank white coffee, three drank white coffee with sweetener and two drank black coffee with sweetener.

Sensory analysis sessions were conducted in University College Cork’s sensory evaluation laboratory which conformed to international standards [14], under white light. For the Sensory Acceptance Testing, untrained assessors (n = 24) evaluated the samples for liking of aroma, liking of flavour and overall accept-
Assessors marked their degree of liking for each sample on a 10-cm-line scale ranging from 0 (extremely dislike) at the left to 10 (extremely like) at the right and rating subsequently scored in cm from the left. For both the Sensory Acceptance and Ranking Descriptive Analysis of the presentation of samples were identical. One coffee was evaluated per session, in which the coffee was presented in the four different presentation methods, simultaneously. Assessors were presented with a black unsweetened coffee, a black sweetened coffee, a white unsweetened coffee and a white sweetened coffee, simultaneously, and asked to rank the samples against each other. The four samples were identical in appearance. A three-digit random code was present on the outside of each of the cups for identification. Each sample consisted of approx. 177 mL filter coffee in 237 mL light brown, single-walled, paper-based cups (methyl cellulose internally and externally coated with polyethylene) and was served at 70 °C. A thermal imaging camera (SATIR Hotfind L-T) was used was used to confirm the temperature of each sample prior to analysis. Samples were presented in a random order in a balanced block design to prevent first order and carry-over effects [15]. Each assessor evaluated each sample in duplicate [16] over a total of four sessions, in which four samples were evaluated simultaneously during each session, with one session conducted per day to prevent fatigue occurring in assessors. Sessions were carried out from 9.30 am - 1.00 pm and took approx. 30 - 50 min.

3.5. Ranking Descriptive Assessors (RDA)

Ranking Descriptive Analysis [17] was undertaken using trained panellists in the age range of 21 - 52 and consisted of 11 males and 13 females. They were also chosen on the basis that they regularly consumed filter coffee. In terms of occupation, two of the males were in professional jobs, eight were postgraduate students and one was an undergraduate student. Out of the females one was in a professional job and several were postgraduate students and five were undergraduate students. Each of the assessors (n = 20) had previously taken part in coffee studies conducted by the team and had training experience in black coffee sensory evaluation. Assessors also took part in determining the sensory terminology of coffee and a sensory term reduction process. A total of 10 attributes were ultimately chosen to profile the products to be tested and which reflected the main sensory variation in samples (Table 1). Trained assessors used descriptive analysis to evaluate the descriptive attributes present in Table 1. Each assessor was asked to rank the intensity of the sample on a 10-cm-line scale ranging from 0 (non-extreme) at the left to 10 (extreme) at the right and rating subsequently scored in cm from left. Samples were presented in a random order in a balanced block design to prevent first order and carry-over effects [15]. Each assessor evaluated each sample in duplicate [16] over a total of four sessions, in which four samples were evaluated simultaneously during each session, with one session conducted per day to prevent fatigue occurring in assessors. Sessions were carried out from 9.30 am - 1.00 pm and took approx. 30 - 50 min.
Table 1. Attributes evaluated (ICO, 2010, [59]).

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liking aroma</td>
<td>How likable is the aroma</td>
</tr>
<tr>
<td>Liking flavour</td>
<td>How likable is the flavour</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>Overall acceptance of the sample</td>
</tr>
<tr>
<td>Smokey/burnt aroma</td>
<td>The smell associated with smoke from burning wood</td>
</tr>
<tr>
<td>Coffee aroma</td>
<td>The unique smell associated with coffee products</td>
</tr>
<tr>
<td>Coffee flavour</td>
<td>Overall intensity of coffee flavour</td>
</tr>
<tr>
<td>Roasted/burnt flavour</td>
<td>The flavour descriptor similar to that found in burnt food</td>
</tr>
<tr>
<td>Earthy flavour</td>
<td>Reminiscent of raw potato flavour and the odour associated with fresh earth, wet soil or hummus. Undesirable in coffee</td>
</tr>
<tr>
<td>Fruity flavour</td>
<td>Reminiscent of fruit flavour</td>
</tr>
<tr>
<td>Sweet taste</td>
<td>Fundamental taste sensation of which sucrose is typical. Generally associated with sweet aroma descriptors such as fruity, chocolate and caramel.</td>
</tr>
<tr>
<td>Bitter taste</td>
<td>A primary taste characterized by a solution of caffeine, quinine and certain alkaloids. The taste is considered desirable up to a certain level and is affected by the degree of roast brewing procedures.</td>
</tr>
<tr>
<td>Astringent aftertaste</td>
<td>Characteristic of an after-taste sensation consistent of a drying effect in the mouth. Undesirable in coffee.</td>
</tr>
<tr>
<td>Full body</td>
<td>Describes the physical properties of the coffee. Full body would describe a strong full mouth-feel as opposed to being thin</td>
</tr>
</tbody>
</table>

4. Data Analysis

ANOVA-Partial Least Square Regression (APLSR) was used to analyse the raw data generated from this study using Unscrambler software version 10.3 (Camo, Norway). The X-matrix was designed as 0/1 variables for coffee samples and the Y-matrix sensory variables. To achieve significant results the regressions coefficient were analysed by Jack-knifing, which is based on cross-validation and stability plots [18]. Table 3 and Table 4 display corresponding P-values of the regression coefficients. A map of the hedonic and descriptive sensory attributes was plotted using ANOVA-Partial Least Squares Regression (APLSR) Analysis.

5. Results and Discussion

SAT is a hedonic sensory technique used extensively for the various food and beverage [19]-[28] products. Figure 1 shows the APLSR plot for the SAT data for the two commercial coffees assessed by the naïve assessors in this study and Table 2 indicates the sample codes visible on the APLSR plot. From Figure 1 and Table 3 it is evident that the presentation of the coffee (black unsweetened, black sweetened, white unsweetened and white sweetened) effects the assessor’s overall sensory experience. For both of the commercial coffee samples evaluated in this study similar results were obtained.
Table 2. Codes present on the PLS plot and the ANOVA value Table.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>Coffee 1 served black</td>
</tr>
<tr>
<td>2B</td>
<td>Coffee 2 served black</td>
</tr>
<tr>
<td>1BS</td>
<td>Coffee 1 served black with sweetener</td>
</tr>
<tr>
<td>2BS</td>
<td>Coffee 2 served black with sweetener</td>
</tr>
<tr>
<td>1W</td>
<td>Coffee 1 served white</td>
</tr>
<tr>
<td>2W</td>
<td>Coffee 2 served white</td>
</tr>
<tr>
<td>1WS</td>
<td>Coffee 1 served white with sweetener</td>
</tr>
<tr>
<td>2WS</td>
<td>Coffee 2 served white with sweetener</td>
</tr>
</tbody>
</table>

Table 3. ANOVA values for regression coefficients from APLSR for the hedonic sensory data.

<table>
<thead>
<tr>
<th></th>
<th>Liking aroma</th>
<th>Liking flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>−0.001***</td>
<td>−0.827 ns</td>
<td>−0.116 ns</td>
</tr>
<tr>
<td>2B</td>
<td>−0.007**</td>
<td>−0.005**</td>
<td>−0.000***</td>
</tr>
<tr>
<td>1BS</td>
<td>−0.000***</td>
<td>−0.009***</td>
<td>−0.001***</td>
</tr>
<tr>
<td>2BS</td>
<td>−0.000***</td>
<td>−0.010**</td>
<td>−0.000***</td>
</tr>
<tr>
<td>1W</td>
<td>0.000***</td>
<td>0.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>2W</td>
<td>0.004**</td>
<td>0.000***</td>
<td>0.066 ns</td>
</tr>
<tr>
<td>1WS</td>
<td>0.000***</td>
<td>0.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>2WS</td>
<td>0.000***</td>
<td>0.926 ns</td>
<td>0.000***</td>
</tr>
</tbody>
</table>

P-values are from the estimated regression coefficients from anova-partial least squares regression (aplsr). The sign dictates whether the correlation is positive or negative. Significance of regression coefficients: ns = not significant, * = P < 0.05, ** = P < 0.01, *** = P < 0.001.

Figure 1. ANOVA-Partial Least Squares Regression (APLSR) correlation loadings plot for the sensory hedonic evaluation for the two coffee samples. Shown are the loadings of the x- and y-variables for the first 4pcs for • = individual treatments, ▲ = sensory descriptor. PC 1 vs. PC 2 presented.
Results accumulated from the naïve assessors showed that the least preferred samples, for both commercial coffees, was when they were served black unsweetened and black sweetened. Coffees served in this manner were negatively significantly ($P < 0.010$) correlated to liking of aroma. Samples 2B, 1BS, 2BS were negatively significantly ($P < 0.010$) correlated to liking of flavour and overall acceptability. Sample 1B was negatively correlated to liking of flavour and overall acceptability, although not significantly.

In contrast, for both coffee samples evaluated, the assessors preferred the coffees when they were served white unsweetened and white sweetened. From Figure 1, in the upper right-hand quadrant of the plot it is evident that samples 1WS, 1W and 2W were positively correlated to overall acceptability and liking of flavour. Thus samples 1W, 2W, 1WS and 2WS were positively correlated to each of the hedonic attributes, with 1W, 1WS and 2WS being positively significantly ($P < 0.001$) correlated to liking of aroma and overall acceptability. Sample 2W was also positively significantly ($P < 0.010$) correlated to liking of aroma. Samples 1W, 2W and 1WS were positively significantly ($P < 0.001$) correlated to liking of flavour.

From the short questionnaire the assessors filled out prior to commencing the trial, it is evident that a total of four of the assessors drink black unsweetened coffee and five of the assessors drink black sweetened coffee in their normal lifestyle, thus this may account for the preference toward white unsweetened and white sweetened coffees in this study. A study with a larger naïve panel could be conducted in future work to strengthen these findings.

RDA is a method extensively used for the descriptive evaluation of various food and beverage [29]-[55] products. Figure 2 shows the APLSR plot for the RDA data for the two commercial coffees assessed in this study and Table 2 indicates the sample codes visible on the APLSR plot. From Figure 2 and Table 4 it is evident that the presentation of the coffee (black unsweetened, black sweetened, white unsweetened and white sweetened) affected the sensory profile of the coffee. Assessors found the black unsweetened coffee positively correlated to each of the descriptive attributes (with the exception of sweet taste and full body). In contrast, assessors found the black sweetened, white unsweetened and white sweetened coffee negatively correlated to the attributes (with the exception of sweet taste and full body).

From Figure 2, in the lower right-hand quadrant it is evident that sample 1B and 2B were positively correlated to earthy flavour. In the upper right-hand quadrant of the plot it is evident that sample 2B was positively correlated to earthy flavour, coffee flavour, coffee aroma, fruity flavour, smokey/burnt aroma, bitter taste and astringent aftertaste. From Table 4, it is clear that sample 2B is positively significantly ($P < 0.001$) correlated to smokey/burnt aroma, coffee aroma, coffee flavour, roasted/burnt flavour, earthy flavour, fruity flavour, bitter taste and astringent aftertaste. Similarly, sample 1B is positively significantly ($P < 0.001$) correlated to smokey/burnt aroma, coffee aroma, coffee flavour, earthy
flavour and fruity flavour. Both samples 1B and 2B were negatively significantly \((P<0.001)\) correlated sweet taste and full body.

From \textbf{Table 4} it can be seen that samples 2BS, 1WS and 2WS are negatively significantly \((P<0.010)\) correlated to smokey/burnt aroma, coffee aroma, coffee flavour, roasted/burnt flavour, earthy flavour, fruity flavour, bitter taste and astringent aftertaste. In contrast, they were positively significantly \((P<0.001)\) correlated to sweet taste and full body.

From \textbf{Figure 2}, in the upper left-hand quadrant of the plot it is evident that sample 1BS is positively correlated to sweet taste and full body. In \textbf{Table 4}, 1BS
is positively significantly \((P < 0.001)\) correlated to these two attributes. It can also be seen that sample 1BS is negatively significantly \((P < 0.010)\) correlated to smokey/burnt aroma, roasted/burnt flavour, earthy flavour, fruity flavour, bitter taste and astringent aftertaste.

From Table 4, it is clear that samples 1W and 2W are negatively significantly \((P < 0.050)\) correlated to smokey/burnt aroma, coffee flavour, roasted/burnt flavour, earthy flavour, fruity flavour, bitter taste and astringent aftertaste. In contrast, they were positively significantly \((P < 0.001)\) correlated to sweet taste and full body. Chiralertpong et al. 2008 [56] reported that sweeteners reduced the roasted and coffee-like notes in coffee beverage and the current results would support these findings.

The results from this present study support results reported by Narian et al. 2003 [57], that a decrease in the intensity of specific attributes occurs during whitening of coffee. As in this present study, the coffees served white (1W and 2W) were negatively correlated to the majority of the descriptive attributes and in contrast, the samples served black (1B and 2B) were positively correlated to the majority of the descriptive attributes assessed.

Narain et al. 2004 [7], carried out a sensory study in which they evaluated assessor preference \((n = 150)\) in various filter coffee blends and examined segmentation. The assessors evaluated twelve different filter coffee samples, over two sessions, as they normally would consume coffee (with/without milk and sugar) and ranked them on a five-point scale. Results indicated that gender had a large influence on coffee presentation style as it was reported that sweetener reduced the hedonic scores in the female assessors and milk increased the preference scores for males. This study was more focused on gaining information on assessor drinking preferences and looking at the difference between commercial coffees available than the presentation styles, as the assessors evaluated each of the coffees how they normally would make coffee. In our study, assessors evaluated two commercial coffees for all four of the presentation styles (black unsweetened, black sweetened, white unsweetened and white sweetened) by ranking the samples against each other. Unfortunately, due to our small panel size \((n = 24)\) we couldn’t segment the results into gender preferences. Cristovam et al. 2000, [6] noted that males and females had different preferences for espressos and espresso-milk coffees. This is an area that deserves future study using both instant and filtered coffee types. Cristovam et al. 2000 [6] also noted that milk changed the panellist’s preference for coffee type, which we can conclude from our present study is true, as the exact same coffee sample was presented in four different presentation styles and white unsweetened coffee and white sweetened coffee was preferred by the naïve panel \((n = 24)\) in this present study.

Narain et al. 2004 [7], also used a trained panel \((n = 13)\) to profile the 12 commercial filter coffees when presented black unsweetened, white unsweetened and white sweetened; however, their results were focused on how each of the individual presentations of the coffee affected 12 different coffees evaluated. In contrast, our study evaluated how four presentation methods compared against
each other for two commercial coffee samples using RDA.

Lundgren et al. 1978, [58] reported that the ability of assessors to assess the degree of liking of sucrose levels in coffee beverages is independent of behavioural responses. It is important to note that for our sensory acceptance testing half of the assessors \(n = 12\) drank coffee without sweetener and the other half of the assessors \(n = 12\) drank coffee with sweetener.

Chiralertpong et al. 2008 [56], evaluated the effect of added creamer and sweetener on espresso coffee samples. They found that coffee-like and roasted notes were reduced by the presence of sweeteners. Our white sweetened coffee sample demonstrated similar results, however our black sweetened coffee samples demonstrated contradicting results.

6. Conclusion

Coffee drinkers have developed a hedonic preference for how they like to imbibe coffee (black, with milk, sweetened etc.). In the present study, by presenting coffee in the different ways (black unsweetened, black sweetened, white unsweetened and white sweetened) allowed us to determine which presentation style untrained assessors prefer \(n = 24\) and also how trained assessors \(n = 20\) perceived the descriptive attributes associated with the different coffee beverages. From this study, it is clear that sweetening and whitening filter coffee has a large influence on how coffee attributes are perceived by assessors. Results showed that when the coffee was served black, the assessors found the descriptive attributes to be more pronounced. In terms of preference, the naïve assessors preferred both coffee samples when they were served white unsweetened and white sweetened.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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