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Description of Coffee Aroma with the Electronic Nose which Learned Wine Aromas, "Le Nez du Vin"

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Abstract: Coffee aroma is considered to be one of the most complicated food aromas which have more than 600 components. For the analyses of total aromas objectively, some electronic noses have been applied and succeeded in distinguishing coffees. However, the feature of coffee aroma (what kind of smell) was not clear with electronic nose techniques, because the results from electronic noses showed the values in resistance/current generally, or distinguish the samples using principal component analyses. Here we present FF-2A electronic nose has the potential to describe coffee aromas like wine experts, comparing with the smells of wine aromas kit, "Le Nez du Vin." Our result showed that canned coffees were similar to Coffee aromas and Mushroom aromas mainly. Although data fitting to human olfactory sensitivity will need in future study, our method will be helpful to describe coffee aromas objectively with electronic noses.

Keywords: Electronic nose; coffee; Le Nez du Vin; wine aroma; similarity; FF-2A; objective description

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1. Introduction

Coffee aroma is considered to be one of the most complicated food aromas which have more than 600 components [1]. As for the components of coffee aroma, recent study showed that the peak areas of 40 important coffee volatiles collected by Solid Phase Micro Extraction (SPME) fiber were different with sampling time [2]. Therefore, it may be difficult to describe total coffee aroma from the components.

For investigation of the coffee qualities, cup tests are usually performed by expert tasters [3]. However, since the quality control by the expert tasters is subjective, it depends on the skill of the tasters [3]. Therefore, there is a problem that only qualified tasters can find the detail quality differences.

Solving the problem with objective techniques, electronic noses were applied to evaluation of the coffees [1]. For example, Gardner et al. succeeded in classifying the several coffee aromas in the rate of 81.1 - 95.5% by the analysis of the headspace of coffee pack with thin oxide sensors array [4]. Rodriguez et al. classified several coffee groups such as healthy coffees, fermented coffees, etc. with metal-oxide gas sensors [3]. However, using general electronic noses techniques, it is difficult to describe the feature of coffee aroma (what kind of smell), because the results from electronic noses showed generally the values in resistance/current, or classify the samples using principal component analyses.

For describing the aroma features objectively, we investigated aroma samples, such as yeast [5], microorganism [6], and mushrooms [7] with FF-2A electronic nose (Shimadzu Corporation). As a special feature of FF-2A electronic nose, it can describe the similarities against the 9 standard gasses, which have known aroma descriptors [5-10]. In our previous study, we expanded the aroma description of FF-2A by recording the smells of wine aromas kit, Le Nez du Vin for describing the 2 types of Colombia coffees (Drip coffee in a coffee shop and instant coffee solution with 90˚C water) [11]. Generally, the Le Nez du Vin is used for learning wine aromas, and it contains 54 aroma solution based on the descriptor of wine aroma or off-flavor, such as Apricot or Tar etc. In the previous paper, we showed that the drip coffee and instant coffee were distinguished and described with different aroma description [11].

In this study, to investigate whether the analysis techniques using the aromas from Le Nez du Vin can describe other types of coffees, we analyzed the aroma from 3 canned coffees (1 black coffee and 2 coffees contains milk, sugar, and flavor).

2. Experimental Section

2.1. Coffee Samples

The 3 canned coffee samples were selected from canned coffee in Japan. Among the coffees, 2 coffees contained sugar, milk, and flavor (named Can 1 and Can 2). The other coffee was black coffee (no sugar, no milk, and no flavor; named Can 3 (black)). The data from drip coffee and instant coffee were referred from our previous paper [11].

2.2. Aroma Samples

We used the previous measured data [11] from the 51 aromas below among the 54 aromas of Le Nez du Vin, French edition (Editions Jean Lenoir) for the calculation of similarities against the wine aromas. The 51 aromas: 1. Abricot (Apricot), 2. Acacia, 3. Amande amere (Almond), 4. Ananas (Pine apple), 5. Anis, 6. Aubepine (Thorn Apple), 7. Banane (Banana), 8. Beurre (Butter), 9. Cacao, 10. Cannelle (Cinnamon), 11. Café (Coffee), 12. Caramel, 13. Cassis (Black currant), 14. Cerise (Cherry), 15. Champignon (Mushroom), 16. Chene (Oak), 17. Citron (lemon), 18. Civette (Chive), 19.Coing (Quince), 20. Eglantine (Wild rose), 21. Foine coupe (Hay), 22. Fougere (Fern), 23. Fraise (Strawberry), 24. Framboise (Raspberry), 25. Fume, 26. Geranium, 27. Girofle (Clove), 28. Goudron (Tar), 29. Iode (Iodine), 30. Muscat, 31. Menthe (Mint), 32. Mercaptan, 33. Miel (Honey), 34. Musc (Musk), 35. Noisette (Hazelnut), 36. Noix (Walnut), 37. Orange, 38. Pivoine (Peony), 39. Pin (Pine), 40. Poire (Pear), 41. Poivre (Pepper), 42. Poivron-vert (Green pepper), 43. Pomme (Apple), 44. Prune, 45. Rose, 46. Soufre (Sulfur), 47.Thyme, 48. Tilleul (Lime), 49. Truffe (Truffle), 50. Viollete (Violet), and 51. Vinaigre (Vinegar).

2.3. Aroma Samples Measurements and Analyses with FF-2A electronic nose

The principle for measurements methods and analyses methods of FF-2A (Shimadzu Corporation, Japan) were described in our previous paper [5]. The 200 μl of the canned coffee samples were collected in 2-liter PET bags (Shimadzu Corporation, Japan) filled with G1 grade dry nitrogen. The bags were allowed to equilibrate for 30 min at room temperature. On the other hand, appropriate quantities of flavor samples (several μl) in Le Nez du Vin were collected in 2-liter PET bag filled with the dry nitrogen, then equilibrated. Since several flavor samples were higher concentration for FF-2A measurement, the headspace volatiles from the high concentration sample were diluted with dry nitrogen in new 2-liter PET bags again, then equilibrated. These equilibrated samples were introduced into the trap tube in FF-2A for 60 sec and then exposed to the 10 sensor array with pure nitrogen gas. All the samples were measured 4 times and the final 3 measurements were used for analyses. For the calculation of similarity, each measurement data were compared to the average data of the 3 measurements about aroma samples or aromas from coffees with Asmell2 software (Shimadzu Corporation).

3. Results and Discussion

As a result from similarities against the 51 wine aromas, the aroma from the canned coffees were similar to 5 aromas including Coffee, Mushroom, Pine, Honey, and Orange aromas (Figure 1). Other 46 aromas were judged as no similarity (similarity = 0) to the canned coffee aromas by the ASmell2 algorithm (data not shown). The aromas of Can 1 and Can 2, which include milk, sugar, and flavor, indicated the similarities against Coffee, Mushroom, and Pine aromas. Additionally, the aroma of Can 2 were also similar to Honey aroma. On the other hand, black coffee (Can 3) was similar to Coffee, Mushroom, and Orange aromas.

Focusing on the similarities against the Coffee aroma, all the canned coffees were more similar to the drip coffee [11] than the instant coffee [11] (Figure 1). However, as for the Mushroom aroma, canned coffees' similarities were less than half of the drip coffee. Moreover, in other detected aromas

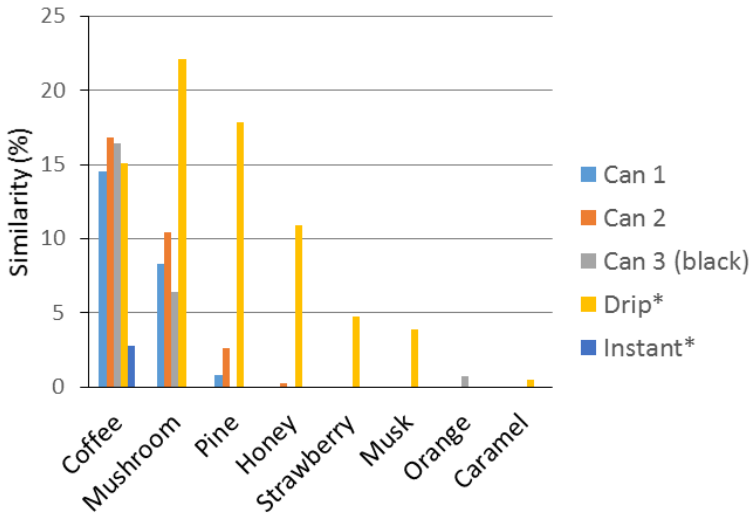
from the drip coffee such as Pine, Honey, Strawberry, Musk, and Caramel [11], the canned coffees were less than 3% or no similarities.

From these data, canned coffees were the most similar to Coffee aroma among 51 wine aromas (Figure 1). In previous report, the instant coffee and drip coffee also indicated the similarity against the Coffee aroma [11]. The drip coffee showed the second highest similarities against the aroma [11]. Since the similarities of instant coffee was the lowest among the coffee samples, this main aroma may be helpful to determine the drip coffee feeling.

Mushroom aroma was similar to canned coffees (Figure 1). As for the real mushroom, one of main aroma components is 1-octen-3-ol [12, 13]. Recent study showed that 1-octen-3-ol was found to contribute to Koku taste (mouthfulness and continuity of the flavor) in seasoning soy sauce [14]. Moreover, 1-octen-3-one, which is similar chemical of 1-octen-3-ol and smells like mushroom or metallic [15], was detected in espresso coffee as one of the main aroma components [2]. From these findings, similarities against Mushroom aromas may suggest the intensity of Koku taste in coffee.

Thus, the FF-2A electronic nose have the potential to describe coffee aromas from canned coffees objectively using the records of wine aroma. However, this method has several points for amelioration. Firstly, similarity with the wine aromas may need data fitting to human olfactory senses, since sensitivity is different between our nose and the FF-2A electronic nose. Secondly, the expansion of descriptors about coffee aroma using coffee specific chemicals will be needed for optimal description. Finally, measurement condition (sample volume, temperature, dilution gas etc.) will need optimization.

Figure 1. Similarities of coffees aromas against the wine aromas in the Le Nez du Vin. The wine aromas which indicate the similarity more than 0 are displayed in the graph. Note: The data from drip coffee* and instant coffee* are referred to our previous report [11]. Moreover, electronic values of wine aromas measured in our previous paper [11] were used for the re-calculation of similarity against the coffee aromas.

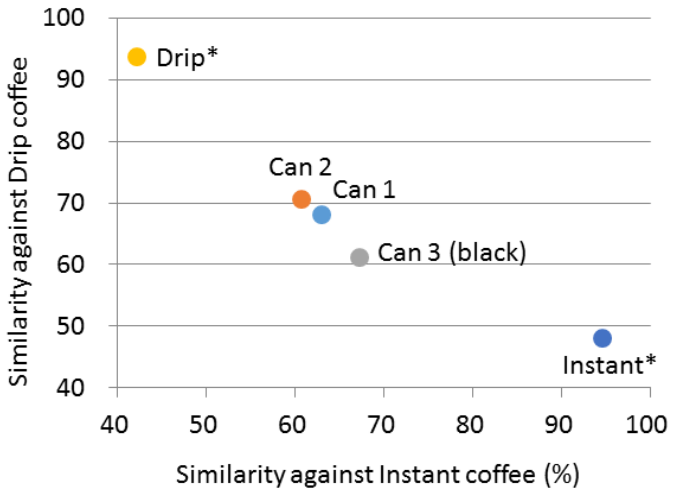


Next, we calculated the similarity of the 3 canned coffees against the average data of drip coffee and the instant coffee (Figure 2). Interestingly, canned coffees were similar to drip coffee and instant coffee in the rate of more than 60.7%, while (1) the similarity of the drip coffee against the instant coffee and (2) that of the instant coffee against the drip coffee were 42.2% and 48.0%, respectively.

These results suggested that canned coffees obtain the different features from the drip and instant coffees, which may reflect the diversity of coffee market.

The aroma from Can 2 was the most similar to drip coffee, while the aroma from Can 3 (black) was the most similar to instant coffee (Figure 2). Although Can 1 and Can 2 samples contains milk, which affects the components of head space aroma [2], they were more similar to drip coffee than the black coffee (Can 3). Although we could not revealed the actual factors, since they also contains food flavor, which was not revealed, the flavor may contributed to the higher similarity against the drip coffee.

Figure 2. Similarities of coffees aromas against the average sensor data from drip coffee and instant coffee (n =3). Note: The electronic values of drip* and instant* coffee measured in our previous report [11] were used for re-calculation of the similarities.



4. Conclusions/Outlook (COMPULSORY)

In this study, the FF-2A electronic nose which learned the Le Nez du Vin wine aroma can describe the aroma from canned coffees. Although this techniques have several points for amelioration, it will be helpful for coffee aroma objectively.

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Author Contributions

Study conception and design: KF, YT, YM; Acquisition of data: KF; Analysis and interpretation of data: KF, YT, NS, YM; Drafting of manuscript: KF.

Conflicts of Interest

The authors declare no conflict of interest.

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