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Investigating Taste Indicator for Coffee Liqueur Manufacturing

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ABSTRACT
Liqueur was an ancient elixir made with various herbal medicinal material soaked in alcohol. Coffee liqueur is also a cordial prepared by soaking coffee with other ingredients in some degree of alcohol. In this study, coffee liqueur prepared with two variable factors, the alcohol percentages (20, 40 and 80%) and soaking period of roasted coffee (14, 21 and 30 days), were tested for the objective tastes. Five tastes (sourness, bitterness, astringency, umami and saltiness) and richness of coffee liqueur were measured by Taste Sensing System. Though correlation between soaking periods and tastes were quite low in general, some tastes, such as saltiness, aftertaste-B, aftertaste-A, umami, astringency and richness, were correlated well with changes of alcohol concentration (R^2, 0.648-0.929). If the high differences (between the minimum and maximum value in each taste) were considered, saltiness, aftertaste-B, aftertaste-A etc. could be the potent taste indicator for coffee liqueur manufacturing.

Key words: Coffee Liqueur, Manufacturing, Taste Analysis, Indicator.

1. INTRODUCTION

Liqueur was one of the useful medicines in ancient times. Peoples in those days tried to find ways to ingest active remedial components from herbal medicines. Extraction of the potent medicinal components by soaking it in alcohol was a very efficient way to remove the other materials except the active ingredients. However, liqueurs became not medicine but very popular drinks especially liked by woman in modern times. Coffee was found by a monk who realized that it could be helpful for them awakening for meditation. In a relatively short period of time (about 1000 years), both Arabs and Europeans had grown quite fond of coffee due to the boom of intellectual discussion culture in coffee houses and as a result became the most consumed drink in the world. In 2018, the EU imported about 2.64 million tons of coffee bean, accounting for 39.4% of the world's consumption, and Korea ranked 6th in the world from roughly importing 150,000 tons (about 22%) [1].Considering the number above, it is apparent that Korean people are fond of coffee much. Whereas liquor causes drowsiness [2], coffee has the opposite effect of increasing alertness. The birth of famous coffee liqueurs such as Kahlua and Tia Maria could be attributed to the positive effect of coffee. However, these two main coffee liqueurs are too thick and sweet, therefore they are utilized as an ingredient for cocktails such as Black Russian, White Russian, B-52 Shot, Espresso Martini etc. That is why various home-made recipes for coffee-liqueur are widely available in the world. Formerly, home-made coffee liqueur recipes were investigated with caffeine contents[3], [4].It was discovered through those researches that caffeine could be employed as an indicator to optimize the manufacturing process. However, if taste is considered to be the key factor in deciding the choice of foods, no one would oppose that human taste sensory test must be the most realistic quality control method for foods. Because taste is the complex chemical reaction between many chemicals and human tongue, a real taste test by a human was the only method figuring it out traditionally. In the food industry, generally, sensory evaluation has been performed by the food taste testing panelists, but the obtained data from the sensory evaluation has been problematic in terms of lack of repeatability and objectivity, due to differences among individuals and the physical conditions of panelists. Therefore, much training is required for the panelists to conduct a reliable sensory evaluation[5].As an alternative to taste measurement by human, an instrumental taste sensing electronic device was developed for measuring the major basic tastes of foods objectively. Hayashi *et al.* developed “a taste sensor equipped with multi-channel electrodes using a lipid/polymer membrane for the transducer”[6].“This taste sensor is considered to be an electronic tongue with global selectivity is defined as the decomposition of the characteristics of a chemical substance into those of each type of taste and their quantification, rather than the discrimination of individual chemical substances, by mimicking the human tongue, on which the taste of foods is decomposed into each type of taste by each taste receptor” [7].The useful areas where the taste sensing device could be applied are supporting sensory evaluation in product development, differentiation of products, quality control and etc. In this research, coffee liqueurs, prepared by different alcohol contents and soaking periods, were tested by Taste Sensing System, followed by analyzing correlation of each taste and recipe condition. Through this process, some tastes are suggested as the potent indicator[8]candidates for coffee liqueur manufacturing.

2. MATERIALS AND METHOD

The recipes considered at Oh's research [4] were adapted. Only the short-summarized methods would be described as follows.

2.1 Coffee and Roasting

Roasted "Ethiopia Sidamo G2" coffee bean was purchased in G roasting lab (Seoul, S. Korea). The coffee bean was cultivated in 1900m alpine zone between October and March. The coffee bean was delivered within 24 hours after roasting. The roasting condition was between medium and high point. And the roasted coffee beans were ground to the size for Espresso (about 0.3mm) by Wiswell coffee grinder (SP-7426, Supreme Electric Manufacture Co.,LTD., Guangzhou, China).For the coffee bean powder ingredient, coffee bean was ground as the particle size of 0.7-1.0 mm. To make an espresso shot, the same machine and method of Oh [4] were adapted.

2.2 Coffee Liqueur Manufacturing

The ingredients list and amount condition are shown in Table 1. Brown sugar (1 kg) and 280 mL of Metier Vanilla SyrupCJ CheilJedang, Seoul, S.Korea) were purchased in lotte mart in Seoul, S.Korea. Fermented rectified ethanol (95%) was purchased from "Korea Ethanol Supplies Company" (Seoul, S. Korea). The ethanol was diluted to 80, 40 and 20%step by step. The order of ingredients addition and method was same to Oh [4]. The manufactured coffee liqueur ingredients mixtures were stored in nine glass jars (Bormioli FIDO white glass jar 1 L, Fidenza, Italy) located in a room without window (17-25°C). Nine jars were consisted with three jar groups with 20%, 40% and 80% alcohol. Each one bottle of each different alcohol % group was opened (and filtered) at 14, 21 and 30 days. The filtered coffee liqueur samples were storedin refrigerator (4°C).

Table 1: Coffee liqueur manufacturing recipe

Ingredients	Amount
Roasted coffee bean	40g
Roasted coffee bean powder	110g
Espresso shot	One (37.5mL)
Brown sugar	150g
Vanilla syrup	15 mL
Fermented rectified ethanol	350 mL

2.3 Taste Analysis

All measurements were performed using "the electronic taste sensor system TS-5000Z (Intelligent Sensor Technology, Inc., Kanagawa, Japan)". TS-5000Z was equipped with five taste sensors of bitterness, umami, saltiness, sourness, and astringency. Each sensor was filled with 0.2 mL inner solution (3.33 M KCl in saturated AgCl solution) provided by Insent Inc (Atsugi-shi, Japan) before taste sensing tests. All sensors were conditioned in standard solution for 24 hours before measurement. The coffee liqueur (the final filtrates) samples were diluted to adjust the final ethanol concentration as 5%. As the first step of an analysis of initial taste, the measurement of a reference solution (Vr) was proceeded, followed by the sample solution (Vs) measurement. The rinsing step was proceeded by the solution consisted with 100 mM KCl and 10 mM KOH in 30% ethanol (v/v %). After the rinsing procedure (two times for 3 second each), the aftertaste (Vr') measurement proceeded followed by the rinsing step for 6 min. The initial taste was calculated by the formula "R=Vs−Vr (sensor output)". CPA value, the change by membrane potential caused by adsorption, was calculated by "CPA=Vr'−Vr (aftertaste sensor output)" [9]-[11].

2.4 Statistical Analysis

The "mean, standard deviation and relative standard deviation (RSD) %", ANOVA test and regression test were calculated by "Sigma Plot version 13 (Systat Software Inc., San Jose, CA, USA)". Taste sensor data were processed using in-built software program of TS-5000Z.

3. RESULTS

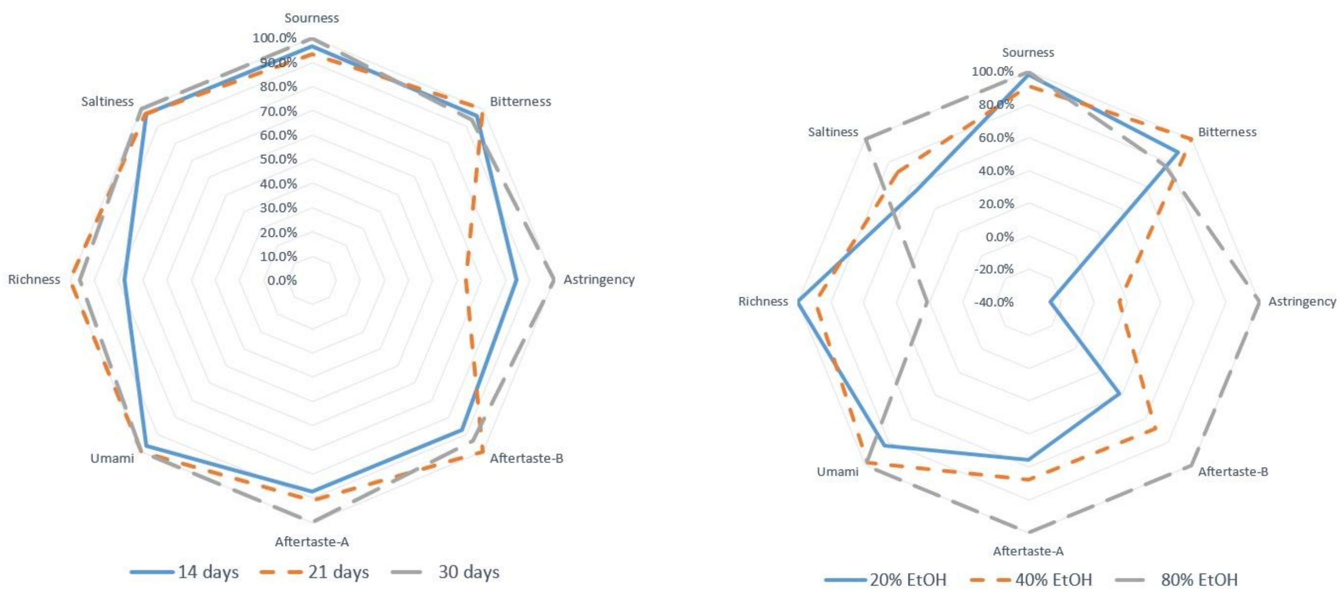
The taste sensation of a person is comprehensively influenced by the various different physicochemical properties of food, such as temperature, volume, viscosity and the individual perception of the tastes, etc. Though there is no exact device that mimics human taste perception, the taste sensing system might be the closest system to human taste perception so far. "The taste sensor has sensor electrodes (working electrodes) to which a lipid/polymer membrane is attached and a reference electrode, and measures changes in the membrane potential generated when these electrodes are immersed in a sample solution" [7].

The taste sensing results (Table 2) show, if there are any significant differences between samples. The difference between "the highest and the lowest value in each column" ranged from 2.14 (bitterness) to 16.33 (saltiness). Among the eight tastes measured by the taste sensing system, saltiness, aftertaste-B, aftertaste-A, and umami values increased with the relatively high correlation coefficients (R^2), 0.987-0.648 by the increase of ethanol ratios, while astringency and richness values were well correlated negatively (R^2s were 0.929 and 0.863, respectively). However, the correlation coefficients between the taste values and the soaking periods were very low (0.002-0.060) which implies that the soaking period of the ingredients in alcoholic solution may not affect the taste values (The very low R^2 mean there is nothing can be explained by the relationship).This phenomenon could be easily acknowledged in Figure 1 where (A) is the spider map of eight tastes for the three data (14, 21, and 30 days soaking). The data for each soaking period are the average value of three alcohol percentage data. (B), Figure 1 is the spider map for the data of three different alcohol percentages (20, 40, and 80%), also average values of three different soaking periods.

Table 2: Taste mean values of coffee liqueurs manufactured with the different ethanol percentages and soaking periods with their statistical results (ANOVA and linear regression data, etc.)

Sample	Sourness	Bitterness	Astringency	Aftertaste-B	Aftertaste-A	Umami	Richness	Saltiness
20%-14days	-18.77[a]	5.41[a]	0.68[a]	3.82[a]	4.49[a]	15.00[a]	4.53[ab]	17.96[a]
20%-21days	-18.77[a]	5.54[a]	0.59[a]	4.06[ab]	4.64[ab]	15.28[b]	4.67[a]	18.98[b]
20%-30days	-21.15[b]	5.85[b]	0.71[a]	4.27[ab]	4.83[c]	15.71[c]	4.32[bc]	18.95[b]
40%-14days	-18.39[a]	6.43[c]	-0.45[b]	7.01[c]	5.59[d]	17.89[df]	3.80[d]	23.58[c]
40%-21days	-18.25[a]	6.41[c]	-0.37[b]	7.57[d]	5.86[de]	18.09[e]	4.18[c]	24.15[c]
40%-30days	-17.77[a]	6.19[d]	-0.31[b]	7.15[e]	5.57[de]	17.96[ef]	4.10[c]	24.00[c]
80%-14days	-20.41[b]	4.91[e]	-2.46[c]	9.59[f]	7.51[f]	17.71[d]	-0.24[e]	33.41[d]
80%-21days	-18.64[a]	5.49[a]	-1.90[d]	11.67[g]	7.87[g]	18.84[g]	1.56[f]	32.10[e]
80%-30days	-20.70[b]	4.29[f]	-3.04[e]	10.47[h]	9.79[h]	18.60[h]	1.58[f]	34.29[f]
Average	-19.20	5.61	-0.73	7.29	6.24	17.23	3.17	25.27
RSD(%)	-6%	13%	-194%	40%	29%	9%	55%	26%
Max-Min[i]	3.38	2.14	3.75	7.85	5.3	3.84	4.91	16.33
Linear Regression Result of ethanol % (independent variable) and raw taste value data (dependent variable)								
R^2	0.051	0.316	0.929	0.927	0.871	0.648	0.863	0.987
+ / –[j]	+	–	–	+	+	+	–	+
Linear Regression Result of soaking periods (independent variable) and raw taste value data (dependent variable)								
R^2	0.060	0.010	0.002	0.005	0.045	0.024	0.022	0.002
+ / –[j]	–	–	–	+	+	+	+	–

[a-h]Means in the same column with same letters are "not significantly different(p<0.05)".
[i]Max-Min is the difference between the highest value and lowest value in the column.
[j]+ / –is the sign of positive or negative correlation.



(A) (B)

Figure 1: Eight taste patterns of the coffee liqueur sample groups for (A) three soaking periods and (B) three ethanol percentages.

Because the taste sensor output (mV) ranges and directions (positive or negative) were different to each other, the values were normalized by the largest value as 100% to display them in one spider map (in case of negative value, the lowest value was designated as 100%). The spider map shape of (A) shows almost same tastes pattern for three different soaking periods, though (B) clearly presents different tastes pattern depending on the alcohol percentages.

The average taste values (of three values from the different soaking periods) of the coffee liqueurs manufactured with the three different ethanol ratios are described in Table 3 with the differences between two different ethanol percentage samples. According to Kobayashi etc. [12], humans can distinguish the "1 unit" of taste sensing value. The four tastes such as astringency, aftertaste-A, aftertaste-B, and saltiness (they showed R^2 from 0.871 to 0.987 between the taste values and ethanol percentages in Table 2), also revealed the taste value differences were over value 1 between the taste mean values for each different ethanol percentage samples (Table 3). The taste mean value differences (by the different alcohol percentages) for bitterness were under value 1 except the difference 1.45 of "80%-40%". However, aftertaste-B (the after taste of bitterness) showed the large differences such as 3.19 of "40%-20%", 3.33 of "80%-40%", 6.53 of "80%-20%" with the high correlation, 0.927 between the taste values and the ethanol percentages. This means that much of the chemicals (in coffee liqueur) affect the bitterness imprecisely. However, for the measuring of aftertaste-B, the pre-step, washing the bitterness sensor two times for 30 seconds with the washing solution, may detach the weakly adsorbed chemicals on the sensor, therefore only the chemicals causing aftertaste-B might remain. The highest taste mean value difference 14.64 was observed in saltiness values (the alcohol ratios "80%-20%"). The saltiness has high taste threshold due to the high-water solubility against hydrophobicity of the lipid molecule. However, the relatively large differences between the saltiness mean values (by the three different alcohol percentages) might make humans differentiate the salty taste better than other tastes of coffee liqueur prepared by the different alcohol percentages. Some ionizable compounds such as sodium chloride, the representative salty chemical with high water solubility (36.0 g/100 g of water at 25°C) [13], may be extracted more by the higher water solution than ethanol having a slight sodium chloride solubility (0.065 g/100 g ethanol at 25°C) [14]. According to Tahara and Toko [7], saltiness taste sensor produced the sensor output (mV) to negative direction as sodium chloride concentration increased. Therefore, humans may sense less saltiness with increased alcohol percentage. In case of umami and richness (aftertaste of umami), the difference values between the different ethanol percentage liqueurs were under the value 1 for two cases which means there may be relatively little chance to differentiate the coffee liqueur product prepared by different recipes (like alcohol content).

Table 3: Taste mean values and the differences between the coffee liqueurs manufactured by different ethanol percentages (20, 40 & 80% ethanol)

Sample	Sourness	Bitterness	Astringency	Aftertaste-B	Aftertaste-A	Umami	Richness	Saltiness
20% [a]	-19.55	5.60	0.66	4.05	4.65	15.33	4.51	18.63
40% [a]	-18.14	6.34	-0.38	7.24	5.67	17.98	4.03	23.91
80% [a]	-19.92	4.90	-2.47	10.58	8.39	18.38	0.97	33.27
40%-20% [b]	1.42	0.74	-1.04	3.19	1.02	2.65	-0.48	5.28
80%-40% [b]	-1.78	-1.45	-2.09	3.33	2.72	0.40	-3.06	9.36
80%-20% [b]	-0.36	-0.70	-3.13	6.53	3.74	3.05	-3.54	14.64

[a] They mean the ethanol percentages of the coffee liqueurs. The following values in each row are the taste mean values of each taste.
[b] They mean the difference between the taste value of the coffee liqueurs with the different ethanol percentage.

4. CONCLUSION

Among the eight tastes tested for coffee liqueurs prepared by the different alcohol percentages and soaking periods, saltiness, astringency, aftertaste-B and aftertaste-A showed high correlation with the different percentages of alcohol utilized for coffee liqueur ingredients soaking. Moreover, their average value differences (according to the alcohol percentages) were all over absolute value 1 that is the unit human can distinguish. Therefore, these four tastes measured by Taste Sensing System could be used as the basic indicators controlling taste quality of coffee liqueur manufacturing. Once the human taste preference is decided for coffee liqueur, these taste indicators will be valuable to control the taste quality that could be changed by any modification of ingredients.

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