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On Extraction from Coffee Beans Using The Underwater Shock Wave

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The coffee beverage widely liked all over the world as articles of taste is extracted from roasted and milled coffee beans. The aroma with volatility compounds is a feature of coffee. A lot of extraction methods of coffee were researched. In this research, the underwater shock wave loading was tried to the roasted coffee bean to improve the extraction efficiency.
The coffee extracted from the hot water by the filter method after the underwater shock wave loading compared the amounts of the extraction by the freeze-drying processing. In addition, extracted the volatility compounds were compared by the gas chromatography analysis. As a result, the change in the content of an excellent effect of the extraction and a volatility compound was confirmed.

Key words: underwater shock wave, extraction, coffee, spalling destruction

1. INTRODUCTION

The coffee beverage widely liked all over the world as articles of taste is extracted from roasted and milled coffee beans. The aroma with volatility compounds is a feature of coffee. There are a lot of researches on the aroma element of coffee [1)2)]. Moreover, the general filter extraction method[3)], the espresso extraction method[4)] and the supercritical extraction method using carbon dioxide [5)] was tried for the efficient extraction.
It is known that the underwater shock wave destroys the cell wall of the plant[6)] . It is thought that this phenomenon generates the expansion wave by the density change that makes the cell wall a boundary, and brings destruction. The improvement of the extraction efficiency was tried by applying this phenomenon to the coffee bean.

2. EXPERIMENT

2.1 Samples

The coffee bean on the market (the blend and mocha) was prepared as a sample for the experiment.

2.2 Experimental set-up

The detonating fuse (made of The Japan Carlit Co., Ltd., detonation speed 6308m/s) and the SEP (made of Asahi-Kasei Industrial Co., Ltd., explosion velocity 6970m/s, density 1310kg/m^3,) were used for the shock wave source, and the electric detonator (made of Asahi-Kasei Industrial Co., Ltd., No.6) was used for detonation. The coffee bean is put in the bottle made of the polycarbonate, and treated by the underwater shock wave loading in the pressure vessel (Figure 1). The distance from the detonating fuse to the sample is 100mm and 200mm. Therefore, the underwater shock wave pressure is 116MPa and 53MPa respectively [7)].

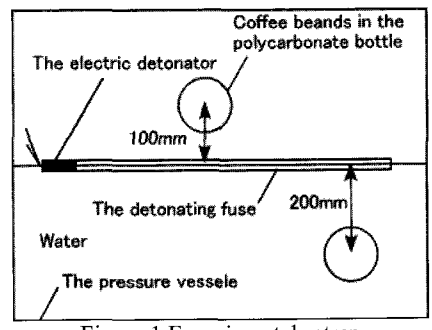

Figure 1 Experimental set up

2.3 Vacuum-freeze drying

The coffee bean of 10g was extracted by using the filter method with hot water 140ml of 90 degrees after the underwater shock wave loading. Extracted coffee 100ml was dried by using the vacuum-freeze drying. And the obtained solid was weighed. The result is shown in Figure 2.

In the untreated by underwater shock wave loading, the obtained extractive is 2.4mg/ml. By the underwater shock wave loading of 53MPa, the extractive is 5.5mg/ml, and about 2.3 times of control. By the underwater shock wave loading of 116MPa, the extractive is 8.3mg/ml, and about 3.5 times of control.

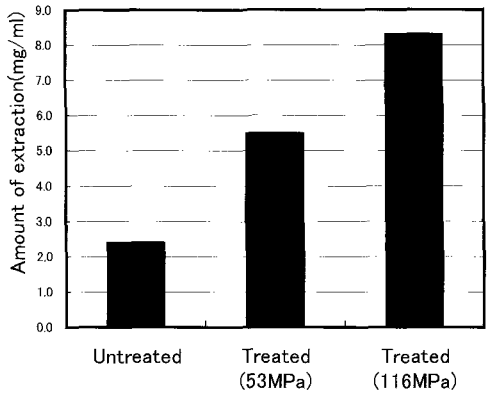

Figure 2 Comparison of the extracted solid from coffee.

2.4 Gas chromatography-mass spectrometry

The extracted material was analyzed by using gas chromatograph GC-8A (column oven-399 °C) made of Shimazu Corporation. The measurement time is 30 minutes for each sample, 140 °C in temperature of the injector, 120 °C in column temperature, and amount 0.1ml of the sample. Figure 8-11 shows the gas chromatogram including the obtained elution curve. Moreover, the peak data is shown in Tables 1 and 2.

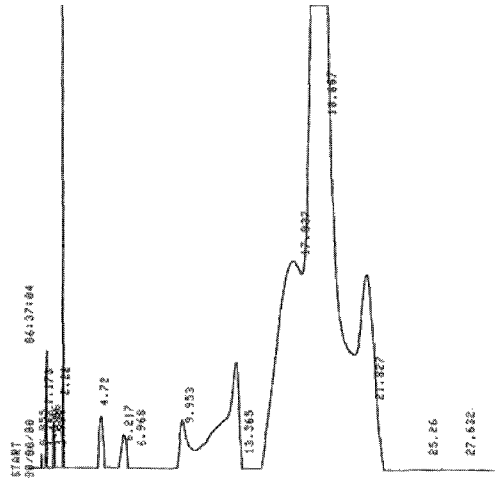

Figure 6 Gas chromatogram of the mocha coffee (Control)

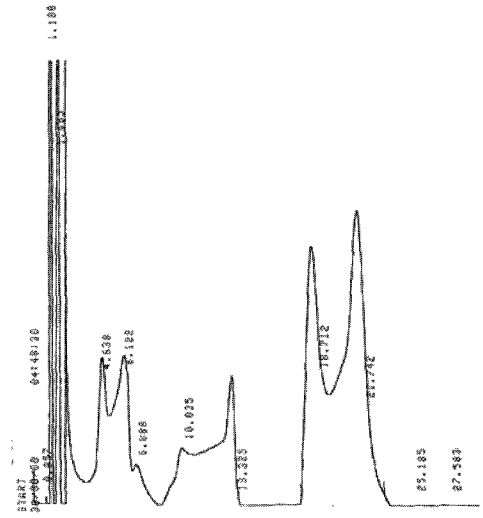

Figure 7 Gas chromatogram of the mocha coffee (treated by the under water shock wave :116MPa)

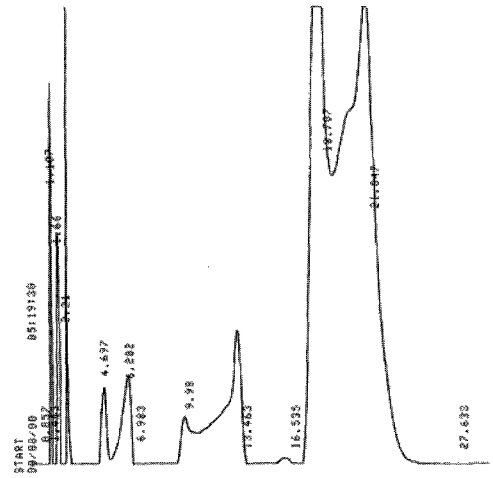

Figure 8 Gas chromatogram of the mocha coffee (treated by the under water shock wave :53MPa)

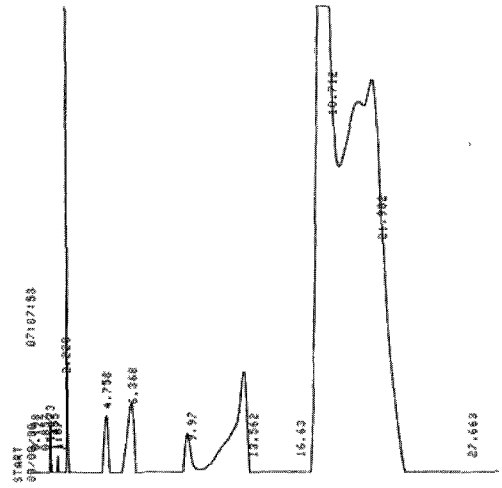

Figure 9 Gas chromatogram of the blend coffee (Control)

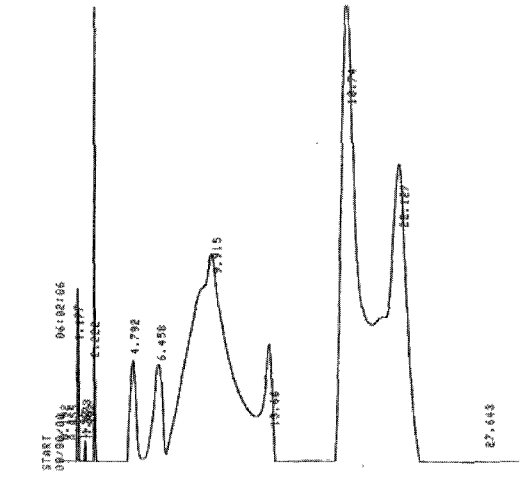

Figure 10 Gas chromatogram of the blend coffee (treated by the under water shock wave :116MPa)

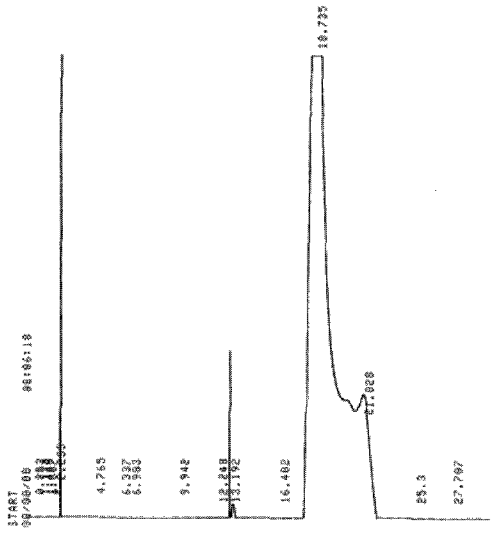

Figure 11 Gas chromatogram of the blend coffee (treated by the under water shock wave 53MPa)

Table 1 The gas chromatography peak data of the mocha coffee

		Control		Treated (53MPa)		Treated (116MPa)	
Peak No.	Time	Area	Conc.	Area	Conc.	Area	Conc.
1	0.855-0.857	5713	0.4937	2320	0.3758	2995	0.2895
2	1.173-1.188	10293	0.8896	25476	10.6062	18643	1.8023
3	1.458-1.463	2803	0.2422	-	-	1564	0.1512
4	1.66-1.685	14150	1.2229	52077	8.4358	25152	2.4317
5	2.21-2.22	48214	4.1669	-	-	55462	5.362
6	4.638-4.72	27261	2.3561	23293	3.7731	22109	2.1375
7	6.122-6.282	38405	3.3192	44925	7.2773	44344	4.2871
8	6.888-6.983	16482	1.4244	7513	1.2169	11724	1.1334
9	9.953-10.035	61956	5.3545	26592	4.3076	46816	4.5261
10	13.325-13.463	127039	10.9793	75811	12.2803	110624	10.6949
11	16.53517.037	192062	16.5989	-	-	35841	3.4651
12	18.707-18.712	461294	39.8673	107526	17.4178	226293	21.8777
13	21.742-21.847	127145	10.9885	199669	32.3437	417042	40.319
14	25.185-25.26	6706	0.5796	1555	0.2518	-	-
15	27.583-27.633	16327	1.411	10579	1.7136	15749	1.5226
TOTAL		1157075	100	617335	100	1034358	100

Table 2 The gas chromatography peak data of the mocha coffee

		Control		Treated (53MPa)		Treated (116MPa)	
Peak No.	Time	Area	Conc.	Area	Conc.	Area	Conc.
1	0.192-0.198	1139	0.1016	1105	0.1122	-	-
2	0.853-0.857	3609	0.322	4401	0.4467	2202	0.2898
3	1.173-1.177	7517	0.6706	13602	1.3806	5485	0.7218
4	1.445-1.455	1994	0.1779	2224	0.2258	1442	0.1898
5	1.667-1.673	11727	1.0461	11722	1.1898	7350	0.9673
6	2.222-2.233	53295	4.7543	50201	5.0954	46421	6.1094
7	4.758-4.792	25908	2.3112	33775	3.4282	21057	2.7713
8	6.337-6.458	61842	5.7844	53286	5.4086	38662	5.0882
9	6.983	-	-	-	-	17111	2.2519
10	9.915-9.97	53875	4.8061	294948	29.9372	46458	6.1143

11	12.248	-	-	-	-	40553	5.3371
12	13.192-13.66	125190	11.168	70340	7.1395	53399	7.0277
13	16.402-16.63	35600	3.1758	-	-	7005	0.922
14	18.712-18.74	282205	25.1751	212591	21.5779	344925	45.3954
15	21.828-22.127	434963	38.8024	222466	22.5802	96652	12.7204
16	25.3	-	-	-	-	9825	1.2931
17	27.643-27.707	19106	1.7044	14562	1.478	21279	2.8005
TOTAL		1120970	100	985223	100	759824	100

3. CONCLUSION

The extraction efficiency of coffee has increased to 3.5 times by the underwater shock wave loading of pressure 116MPa.

In crushing the coffee bean with the mill, an individual cell is not destroyed. In the action of the frictional heat, the possibility that the aroma element is ruined is higher. In case of the shock wave, it destroys the coffee bean when spreading as a pressure medium, the expansion wave is caused by the density difference in the cell tissue and the organization is destroyed. The required time is extremely short in the destruction action. Therefore, the action of heat is never received, and the aroma element is not ruined easily.

It will be necessary to research the improvement of the effect of the extraction using the underwater shock wave loading by analyzing a more detailed smell element in the future.

4. REFERENCES

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