Effect of the blending ratio of oat milk and coconut juice on the flavor of oat coconut juice beverages

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Abstract: Based on the different compounding ratios of oat coconut juice beverages, the influence of the flavor of the compounded beverage was investigated. The volatile flavor components of different proportions of oat coconut juice beverages beverages were analyzed by solid-phase microextraction-gas chromatography-mass spectrometry (SPME-GC-MS) technique, and the appropriate proportion of oat coconut juice beverages beverages was selected. The analysis results showed that 37 flavor compounds (11 co-contained components) were identified in five different ratios of oat coconut juice beverages, mainly including ketones, aldehydes, esters, alcohols, alkanes and alkenes. The coordinated effects of compounds such as hexanal, nonanal, decanal, D-limonene, ethyl nonanoate, ethyl laurate, ethyl octanoate and ethyl decanoate were initially determined to play an important role in contributing to the unique flavor of compounded oat coconut juice beverages. Through the investigation of the comprehensive sensory evaluation and quality indexes, the best compounding ratio of oat coconut juice beverages beverage was initially screened as 8:2.

1. Introduction

Oats as the highest nutritional value of cereal crops, known as the "nine grains of excellence"[1]. The health-promoting compounds in oats include not only beta-glucan but also a series of phytochemicals, such as C-type avenanthramides, A-type avenanthramides, triterpenoid saponins, steroidal saponins, phenolic acids, flavonoids, and vitamins[2]. Oats play an active role in lowering sugar and fat, lowering cholesterol, regulating intestinal flora, losing weight and enhancing immunity[3].

Coconut, a tropical woody plant of the genus Coconut in the palm family, is widely distributed in tropical and subtropical regions, enjoying the reputation of "coconut tree of life"[4]. Coconut edible parts are mainly coconut meat and coconut water, of which coconut meat (the solid endosperm of coconut), its high nutritional value, rich in protein, carbohydrates, dietary fiber, vitamins and other nutrients[5].

In recent years, plant-based cereal beverages are favored by consumers and have become an indispensable part of consumers' beverage options, enabling rapid development in the market[6]. Although China has a wide range of oats planting geographic area, production is abundant, but the extraction of oats functional ingredients products, oat beverages and other deep processing products production was low, the added value of the product has not been higher utilization[7]. In the face of fierce competition from foreign plant-based products, creating distinctive plant-based functional differentiated products is the core competitiveness of local plant-based cereal beverage products in China[8]. Therefore, in order to further develop deep-processed oat products, we must focus on technological innovation as the core, fundamentally stimulate the inherent flavor and nutrients of oats, thereby enhancing the added value of oat products, which is particularly necessary.

Based on two raw materials, oats and coconut, we expect to develop one kind oat coconut juice beverages with good taste, good color, pleasant flavor and high nutritional quality index. The utilization and development of oat and coconut resources in China will increase new social demand and economic benefits, and help to promote the development of coconut and oat industries.

2. Experimental materials and equipment

2.1 Experimental Materials and Reagents

Raw materials Oat seeds: purchased from Hebei Zhangjiakou Jianjun Oat Food Co., Ltd.;Golden coconut : Hainan Coconut Fai Food Co., Ltd.; Monoglycerides: Jialex Additives (Haian) Co., Ltd.; Medium temperature amylase (BAN 480 L)and Glucoamylase (AMG 300 L): Novozymes (China) Biotechnology Co., Ltd.; Sodium carboxymethyl cellulose : Shanghai Shen Guang Edible Chemical Co., Ltd; β-cyclodextrin: Mengzhou Huaxing Biochemical Co., Ltd.

2.2 Experimental instruments and equipment

HH-6 constant temperature water bath: Changzhou Aohua Instruments Co., Ltd; T 25 digital ULTRA-TURRAX homogenizer: Germany IKA Eka; GCMS-QP2010 Ultra Gas Chromatography-Mass Spectrometry, Japan Shimadzu Production Institute; Tam-100 TG series fast bean grinding and de-slagging machine: Shanghai Tiangang Machinery Manufacturing Co., Ltd.; 50μm diethyl phenyl/carbon molecular sieve/polydimethylsiloxane (DVB/CAR/PDMS) extraction head: Supelco, USA.

3. Experimental method

3.1 Preparation of oat coconut juice beverages

Optimize the preparation process of oat coconut juice beverages after preliminary experiments: oat seeds (soaked for 10-12h) - hot scalding (100℃, 3min) - grinding (material-liquid ratio 1:5, grinding twice) - enzymatic digestion (0.2% medium temperature amylase, liquefaction temperature 80℃, liquefaction time 50 min; 0.1% glucoamylase, enzymatic digestion temperature 55℃, enzymatic digestion time 1h) - filtration (80 mesh, 200 mesh two passes sieving), to be used.

Coconut meat (peeled and cleaned) - grinding (material-liquid ratio 1:5, ground twice) - addition of stabilizer (0.3% sodium carboxymethyl cellulose, 0.5% monoglycerides) - blending (oat milk and coconut milk in the ratio of 6:4, 7:3, 8:2, 9:1, 10:0) - homogenization (homogenizer: 10000 rpm/min, 5 min) - bottling - venting - sterilization (15 min pasteurization in boiling water) - finished product.

3.2 Determination of soluble solids of oat coconut juice beverages

Soluble solids were measured by referring to the method in Chapter 4 of GB/T 12143-2008 General analytical method for beverages.

3.3 Determination and evaluation of protein content of oat coconut juice beverages

The protein content was determined with reference to the first method in "Determination of Protein in Food" GB/T5009.5-2016 with a nitrogen conversion factor of 5.83.

3.4 Determination of stability of oat coconut juice beverages

The five samples were measured in parallel three times, and a certain mass was accurately weighed into the centrifuge tube, and the total mass of the sample plus the empty centrifuge tube was m_1, centrifuged at 5000r/min for 20 min, and the supernatant was discarded, the centrifuge tube containing the precipitate was accurately weighed m_2.The centrifugal sedimentation rate of the sample was calculated according to Equation (1). The smaller the centrifugal sedimentation rate, the better the stability of the sample[9].

$$\text{Centrifugal sedimentation rate}=\frac{m_1}{m_2}\times 100\% \tag{1}$$

3.5 Color difference analysis of oat coconut juice beverages

The CIE color parameters of oat coconut juice beverages were determined using a high-precision spectrophotometer. The standard black and white plate was used for calibration. l* value indicates brightness, positive and negative values indicate its brightness and darkness; a* value indicates red and green, positive value indicates close to red, negative value indicates close to green; b* value indicates yellow and blue, positive value indicates yellowish, negative value indicates blueish.

3.6 Sensory evaluation of oat coconut juice beverages

The results were modified according to the actual finished product characteristics, as shown in Table 1. The panel was composed of ten food-related professionals, and the sensory scores of oat coconut juice beverages with different compounding ratios were based on three different dimensions at room temperature: appearance, flavor and taste. To ensure the accuracy of the scores, the professionals were required to follow the professional sensory evaluation requirements during the tasting of the compounded oat milk[10]. The weights of appearance, aroma and taste were determined to be 0.20, 0.35 and 0.45 respectively, and the total score of the beverage was 100.The final sensory score of each beverage was calculated as in equation (2), and the final sensory score of each beverage was the average of the scores given by the evaluators.

$$Y=0.20A+0.35B+0.45C \quad (2)$$

Y: total score, A: appearance score, B: flavor score, C: taste score.

Table 1 Table of sensory evaluation criteria of oat coconut juice beverages

Project	Evaluation criterion	Score
Appearance	Emulsion is uniform, milky white, without precipitation.	81-100
	Emulsion is stratified, milky white, no precipitation	61-80
	Emulsion is stratified, milky white, with precipitation	41-60
	Emulsion is stratified, with miscellaneous colors, with precipitation	0-40
Flavor	Oat aroma and coconut aroma coordinated, no off-flavor	81-100
	Oat aroma and coconut aroma are slightly light, no odor	61-80
	Oat aroma and coconut aroma are very light, no odor	41-60
	Off-odor	0-40
Taste	Fine, silky texture, thick aftertaste, moderate sweetness	81-100
	Slightly thick or thin, with a slightly light aftertaste, or slightly sweet	61-80
	Very thick or thin, light aftertaste, or not sweet	41-60
	Rough taste, astringent, too sweet or not sweet	0-40

3.7 Volatile flavor component analysis

3.7.1 Extraction method

The sample was accurately weighed 6 g (±0.01 g) into the headspace extraction bottle, equilibrated at 60°C for 10 min, and the DVB/CAR/ PDMS extraction head was inserted into the headspace bottle and the extraction head was pulled out after 30 min of adsorption[11]. After sampling was completed, the extraction head was immediately inserted into the gas chromatograph to resolve the components to be measured and analyzed by mass spectrometry.

3.7.2 Instrument parameters

Chromatographic conditions: GC-MS was performed on an Rts-5MS column (30m×0.25mm, 0.25μm) with no split injection and high purity helium (99.999%) as the carrier gas at a flow rate of 0.8mL/min. The column program temperature rise set to a starting temperature of 40 ℃, constant temperature for 4 minutes and ramp up to 50 ℃ at a rate of 4 ℃/min, and then the temperature was increased to 120 ℃ at a rate of 6 ℃/min, followed by 230 ℃ at a rate of 8 ℃/min, and finally constant at 230 ℃ for 10 min.

Mass spectrometry conditions: Ionization method was EI; electron bombardment energy 70 eV; ion source temperature 230 ℃; scan interval 0.13 s; transmission line temperature 250 ℃; mass scan range 33-500 u[12].

3.7.3 Qualitative and quantitative methods

The volatile flavor components were determined by searching each peak through the NIST 11 spectral library, taking the substances with similarity greater than 80%, and qualifying the substances with literature reports. Only compounds with relative content ≥0.1% were counted, and the relative content of each volatile flavor component was determined by the area normalization method.

3.8 Data analysis

All experiments were conducted three times and the mean was taken, and the statistical software was used for statistical analysis of data using Excel 2010.

4. Results and analysis

4.1 Quality index of oat coconut juice beverages with different ratios

Table 2 Quality index of oat coconut juice beverages with different proportions

Compounding ratio	Protein content(g/100g)	Soluble solids content(%)	Color difference value			Centrifugal sedimentation rate(%)
			L*	a*	b*	
6:4	0.77	5.96	61.43	-1.43	1.04	10.58
7:3	0.82	6.59	57.06	-1.64	0.67	12.62
8:2	0.89	7.42	57.76	-1.81	0.48	15.49
9:1	0.98	7.93	55.87	-1.98	0.45	16.00
10:0	1.00	8.63	55.12	-2.04	0.85	17.10

The quality indexes of oat coconut juice beverages can directly reflect its basic characteristics and quality. Among them, the color difference will visually affect the consumer's purchase and consumption index. Soluble solids content, protein, centrifugal sedimentation rate were all important indicators to evaluate the quality of food, which can directly reflect the content and stability of the main nutrients in the product[13].As can be seen from the analysis in Table 2, there were significant differences in the quality indexes of different proportions of oat coconut juice beverages. The lowest value of 10.58% was obtained by centrifugal sedimentation of oat coconut juice beverages in the compound ratio of 6:4. The change in color difference value was mainly influenced by the amount of coconut juice added. The highest protein content of compounded oat coconut juice beverages ratio was 10:0.In the determination of soluble solids, oat coconut juice beverages with a compound ratio of 10:0 had the highest soluble solids content. The overall quality index of oat coconut juice beverages with the compounding ratio of 8:2 was in the middle position and relatively stable.

4.2 Effect of different roasting temperatures on volatile flavor components of oat milk

Different proportions of oat coconut juice beverages volatile flavor components were extracted by SPME and analyzed by GC-MS to retain compounds with a match ≥ 80.The peak area normalization method was used to calculate the relative contents of each component in the chromatograms of five different ratios of oat coconut juice beverages, and a total of 37 volatile compounds (11 co-contained components) were identified, including 2 ketones, 8 aldehydes, 7 esters, 7 alcohols, 12 alkanes, and 1 alkene. Among them, the compounding ratio 6:4, compounding ratio 7:3, compounding ratio 8:2, compounding ratio 9:1, and compounding ratio 10:0 had 22, 23, 19, 28, and 26 major volatile flavor components, respectively. Only 11 of these volatile compounds were co-contained, and the co-containing volatile compounds were D-limonene, hexadecane, pentadecane, tetradecane, dodecane, decanal, nonanal, 2,2,4-trimethyl-1,3-pentanediol diisobutyrate, trans-2-dodecen-1-ol,and Cyclopropyl methanol (See Table 3).

Table 3 Types and relative contents of volatile flavor components of different ratios of oat coconut juice beverages

Category	Name	Retention time(min)	Relative content(%)				
			6:4	7:3	8:2	9:1	10:0
Ketones	l-Menthone	22.587	—	0.18	0.42	0.17	—
	5,9-Undecadien-2-one, 6,10-dimethyl	33.055	—	—	—	—	0.44
Aldehydes	Hexanal	6.433	4.17	10.79	12.89	15.54	4.52
	Nonanal	20.943	5.57	6.47	4.99	4.92	5.56
	Decanal	24.104	4.72	7.40	3.09	9.73	9.22
	Undecanal	34.6	—	0.79	—	—	—
	Dodecanal	32.002	—	—	—	0.47	0.56
	Tetradecanal	36.745	—	0.32	—	—	0.38
	Pentadecanal	40.182	—	—	—	0.76	0.77
	4,8,12-Tetradecatrienal, 5,9,13-trimethyl	40.403	1.32	—	—	0.63	0.68
Esters	Dodecanoic acid, ethyl ester	36.306	1.27	0.97	0.71	0.54	—
	Nonanoic acid, ethyl ester	24.045	0.65	0.36	0.33	0.25	—
	Octanoate <ethyl->	23.8	2.64	1.67	0.88	—	—
	2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	36.179	0.62	0.48	0.37	0.41	0.54
	Decanoic acid, ethyl ester	31.476	1.86	1.41	0.93	0.37	—
	1,2-Benzenedicarboxylic acid,bis(2-methylpropyl) ester	40.827	0.35	0.17	—	0.70	0.47
	Isopropyl palmitate	43.072	3.09	—	—	1.92	2.48
Alcohols	Cyclopropyl carbinol	5.017	0.06	0.08	0.11	0.08	0.06
	1-Nonanol	23.986	—	—	—	—	0.41
	Menthan-3-ol	23.267	—	0.36	0.70	0.77	0.64
	Undec-2-ene<1-hydroxy->	38.545	—	—	—	—	0.39
	1-Hexadecanol	41.113	3.79	—	—	2.09	3.84
	trans-2-Dodecen-1-ol	23.05	2.82	3.34	2.68	3.41	4.04
	Dodecane, 4,6-dimethyl	26.633	—	0.16	—	0.11	0.19
	1-Hexanol,5-methyl-2-(1-methylethyl)	24.413	1.21	0.89	—	—	—
Alkanes	Dodecane	23.912	1.45	1.34	1.26	1.07	0.39
	2,6,10-Trimethyltridecane	42.749	0.16	—	—	0.13	—
	Tridecane	27.794	—	—	0.35	0.37	—
	Tetradecane	31.634	2.14	2.00	2.14	1.56	2.02
	Pentadecane,3-methyl	35.856	0.12	0.13	—	—	0.19
	Pentadecane	34.301	1.55	2.42	1.07	0.75	1.16
	Hexadecane,2,6,10,14-tetramethyl	39.956	—	—	—	—	0.28
	Hexadecane	36.442	1.16	1.19	0.99	1.14	1.26
	Eicosane	41.334	—	—	0.22	0.77	1.00
	Hexacosane	42.091	—	—	—	0.46	—
	Dotriacontane	41.488	—	—	—	0.76	—
Alkenes	D-Limonene	18.127	0.64	0.40	0.48	0.48	0.90

Note: "-" means not detected.

Research has shown that hexanal, nonanal, ethyl octanoate, ethyl decanoate, and other key flavor substances in coconut fragrance. Overall, ester compounds impart a unique coconut fragrance [14].Four flavor substances, ethyl nonanoate, ethyl laurate, ethyl caprylate, and ethyl caprylate, had varying degrees of effect on the compounding ratio of coconut oats, and their levels continued to decrease until the compounding ratio of coconut oats was 10:0 and was no longer detected.The four flavor substances 6,10 -dimethyl, 5,9 -undecadien-2-one, 1-nonanol, 2 -undecenol, and 2,6,10,14 -tetramethylhexadecane were detected only in the coconut oats compounding ratio of 10:0.The results showed that the detection of these four compounds was associated with an increased addition of oat milk as a key characteristic volatile flavor substance of pure oat milk.The 3 volatiles, eicosane, n-pentadecanal and dodecanal, increased gradually with the decrease of coconut juice addition after the compounding ratio of 9:1 and 10:0.

The main volatile flavor compounds in oat coconut juice beverages were compounds such as hexanal, nonanal, decanal, ethyl nonanoate, ethyl caprate, ethyl octanoate, ethyl laurate, D-limonene, etc. From the results of the characteristic search of flavor substances, the main compounds were fatty flavor, rose flavor, nutty flavor, and citrus flavor.Under general conditions, alkane compounds have a weak flavor activity and high threshold, and contribute less to the flavor of oat coconut juice beverages, and were not the main flavor-forming compounds. Therefore, no further follow-up analysis of the alkane compounds was done.

4.3 Sensory evaluation of different ratios of oat coconut juice beverages

In order to understand the flavor effect of different ratios of oat coconut juice beverages, 10 food professionals were invited to conduct sensory evaluation of their compounded oat coconut juice beverages drinks based on three different dimensions of appearance, aroma and taste according to the sensory evaluation criteria table, and the evaluation results were showed in Figure 1. The overall sensory evaluation scores of five different proportions of coconut milk and oat milk, from low to high, were as follows: composite ratio 8:2 (82 points), composite ratio 9:1 (80 points), composite ratio 10:0 (79 points), composite ratio 7:3 (76 points), and composite ratio 6:4 (73 points). The product achieved the highest overall sensory evaluation score of 82, exhibiting a uniform organizational structure, good color, and no sedimentation; the oat aroma and coconut aroma were well-balanced; the texture was slightly thick, with a slightly sweet aftertaste.

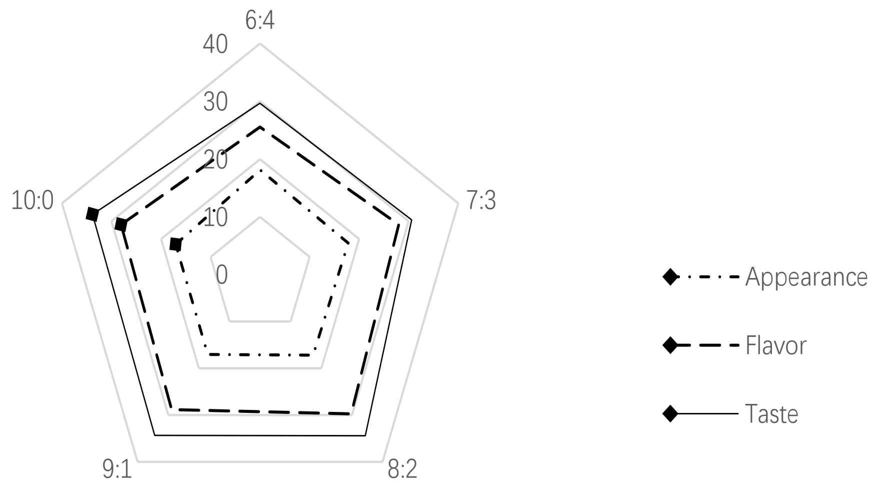

Fig. 1 Radar chart for sensory evaluation of oat coconut juice beverages

Differences in the amount and relative content of flavor volatile substances were important factors contributing to the differences in the overall sensory scores of different proportions of oat coconut juice beverages drinks.

The highest overall sensory score of the compound ratio of 8:2, the content of volatile flavor components such as ethyl laurate, ethyl nonanoate, ethyl caprylate, ethyl caprylate and isopropyl palmitate esters was relatively low, and the ester compounds had strong fruit flavor and coconut aroma.In addition to hexanal, nonanal and decanal have low content. Aldehydes have pleasant odors such as fruity and fatty flavors. The rich variety of aroma substances and the coordinated synthesis of trace amounts greatly enrich the overall flavor substances of oat coconut juice beverages and make its aroma composition richer.

The compound with the lowest overall sensory score of 6:4 had a relatively high content of volatile flavor components mainly esters and alkenes: ethyl laurate, ethyl nonanoate, ethyl caprylate, ethyl caprylate, isopropyl palmitate, and D-limonene.In addition to nonanal, hexanal, decanal its content was low, but also may be due to the more intense release of ester compounds flavor, rich aroma substance species, the content of the uncoordinated, so that the flavor of coconut milk and oat milk was not coordinated enough, its overall flavor presentation was poor.

From an overall perspective, in different proportions of oat coconut juice beverages with esters with strong fruit flavor and coconut flavor aroma (such as ethyl laurate, ethyl nonanoate), aldehydes with fruit flavor, fatty flavor (such as nonanal, decanal) the better the overall coordination of flavor compounds, the more likely the product flavor was recognized.

5. Conclusions

The volatile flavor differences of five different ratios of oat coconut juice beverages were analyzed by SPME-GC-MS technique to investigate the variation of volatile flavor compounds present in different ratios of oat coconut juice beverages.The volatile flavor of compounded oat coconut juice beverages is mainly generated during the preparation process of milling, liquefaction,enzymatic digestion, homogenization, sterilization and storage.A total of 37 compounds were identified by SPME-GC-MS technique, and the main contributing volatile flavor components were determined by calculating ROAV.The results showed that the richer the number of volatile flavor components in the process of compounding the two ingredients, the richer it was in relative terms, not the better it was for their overall flavor.The oat coconut juice beverages with a compounding ratio of 8:2 was richer in volatile flavor components and its relative content was coordinated without strong volatilization, making its overall flavor harmonious and highest in the overall sensory score.The oat coconut juice beverages with the compounding ratio of 6:4 was richer in volatile flavor components and content, with a variety of more prominent flavor substances evaporated strongly, and the flavor coordination of the two ingredients was not balanced enough, making its overall flavor poor, and the lowest score in the overall sensory score.Through the overall evaluation, the oat coconut juice beverages with the compounding ratio of 8:2 has good color, flavor and taste, and its quality index also performs better, which can be used as the preferred ratio for compounding plant-based oat milk.About different ratios of coconut juice oats milk as compounding the best ratio and its flavor type, other differences in quality indicators exist, still need to be compared and explored, extraction and testing of functional substances,Increasing the nutritional quality ofoat coconut juice beveragescan also be further studied in depth.

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