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Differences, Correlation of Compositions, Taste and Texture Characteristics of Rice from Heilongjiang China

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Abstract

In this research, differences in composition, texture characteristics and sensory features of twenty kinds of rice from Heilongjiang China were studied. Experimental results showed significant differences in content of fat, amylose and protein however those differences were not extended to perceived taste evaluation by sensory evaluation. Hardness was measured from 363.6 gs to 1120.3 gs by TPA from 6103.7 g to 11641.1 g adhesiveness, springiness was from 0.4 to 0.6, gumminess was from 2538.9 to 6373.9 and resilience was from 0.2 to 0.3. According to correlate analysis between the chemical composition and taste of rice, we derived that more fat led to more springiness, more protein led to lower viscosity but better hardness and springiness, higher amylose content resulted lower viscosity and taste but higher springiness as well as higher carbohydrate content resulted higher viscosity but lower hardness and springiness. After correlate analysis between chemical composition and the texture characteristic of rice, it was concluded that moisture content was negatively correlated with hardness, gumminess and adhesion, while significantly correlated with resilience; the content of protein was negatively correlated with adhesion but positively correlated with hardness, cohesiveness, gumminess and significantly positively correlated with resilience; the content of ash and adhesion were negatively correlated. The adhesiveness of texture characteristic and the viscosity of taste showed significant positive correlation, and the cohesiveness and resilience of texture characteristic were positively correlated with the softness of taste index.

Keywords: Rice; Texture characteristics; Chemical composition; Gelatinization properties; Correlation

Introduction

In 2014, China produced 607 million MTs of grain. However rice is one of the most popular staple foods, and today half of the world population are living depend on it in Asia, Southern Europe, tropical America and some parts of Africa, and the total production is ranked 3 among the world's total crop yields [2]. The area of Heilongjiang is located in the center of the northeastern Asia economic zone, which is one of the three world famous black soil zone [3] and the rice produced from Heilongjiang is popular with acceptable quality. Although already in the market with good appearance in terms of surface (reflective and translucent), the rice fragrance and taste have some problems concerning sensory properties during consumption. So it is important to evaluate the composition characteristics of the different rice cultivated in the Heilongjiang area in order to assess composition effects on sensorial and textural quality.

The chemical composition of rice determines its nutritional value and sensory properties such as taste and texture [4,5]. Amylose content in the starch has been identified as one of the main composition components that affect its textural properties [6]. Moisture, protein and fat content also have some effects on perceived taste and hardness of rice when being consumed [7]. Parameters to assess the quality of starch have been largely discussed such as Xu-mei et al. [8] proposed that texture could be considered as one of the key parameters. However, in many cases the perceived texture is associated to taste, thus it would be important to relate textural and taste properties of rice and to evaluate how they are affected by the composition. This is an objective of interest in areas such as the Heilongjiang region where the production of rice has a large economic impact that has been negatively affected by the variable quality of the rice produced in the region. Guoxingfeng and Muyundong [9] determined the texture properties of rice after cooking from different regions using standard textural protocolsand the research indicated that there existed significant difference between hardness and viscosity through variance analysis. Lufeng et al. [10] measured the hardness, viscosity, springiness and chewiness of rice by Texture Analyzer. Similar research, Nithya et al. determined the influence of moisture content, particle size and level of cereal-pulse blend on the glass transition and melt temperatures of a ready to eat cereal-pulse formulation.

Given the economic importance of rice production in the Heilongjiang region and the rising concerns regarding quality in terms of sensorial properties it is important to evaluate the effect of composition on these properties and that was the main objective of the present research orientation. For that the chemical composition of 20 types of rice coming from this region was evaluated. The following properties of cooked rice were evaluated using Textural Profile Analysis (TPA) and sensory evaluation. Correlations among the chemical composition of the rice types and their mechanical and sensory properties were evaluated at the same time.

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Materials and Methods

Materials

Heilongjiang rices: No.1-5 from Fangzheng County, No.7-9 from Wuchang City, No.10 produced in Wangkui County, No.11 produced in Suihua City, No.12 produced in Qingan County, No.13 produced in Yilan County, No. 14 and 15 produced in Jiamusi City, No.16 from Muling City, No.17 from Dongning County, No.18, made in Ning'an county, No.19 and 20 made in Qiqihar City. All the samples were stored at 14and 53% humidity.

Preparation of rice flour

Rice was ground using a FZ102 roll mill and sieved using a 100 mesh screen. The moister content was between 12% and 14% by dry milling.

Project	Grading standard	Score
Viscous 10min	smooth, viscous, non-stick teeth	7-10
	viscous, basic non-stick teeth	4-6
	sticky or non-stick teeth	0-4
Hardness 10min	soft hard moderate	8-10
	hard or soft	4-7
	very hard or very soft	0-3
Springiness 10min	chewy	7-10
	texture slightly	4-6
	loose, dry	0-4

Table 1: Valuator texture scoring criteria of rice.

Sample number	Hardness /g	Adhesiveness /gs	Springiness	Cohesiveness	Gumminess /g	Resilience
Daohuaxiang	9595.7	-737.7	0.46	0.5	5057.6	0.3
Fragrant rice of China	8680.8	-791.5	0.45	0.4	3876.8	0.2
Organic rice	8339.1	-877.4	0.48	0.5	3787.2	0.2
Selenium enriched rice	8689.0	-601.4	0.47	0.5	4405.7	0.3
Qiuran rice	7679.3	-445.6	0.41	0.4	3346.0	0.2
Long grain fragrant rice	8156.9	-669.4	0.43	0.5	4233.1	0.3
639 rice	8569.6	-1011.3	0.46	0.5	4414.5	0.3
Daohuaxiang rice	9177.7	-731.6	0.40	0.5	4761.1	0.3
Wuchang fragrant rice	6988.6	-470.6	0.38	0.4	2797.6	0.2
Wangkui rice	9804.3	-1120.3	0.53	0.5	5179.9	0.3
Suihua rice	6613.2	-868.9	0.39	0.4	2731.0	0.2
Qing`an rice	8836.2	-452.4	0.43	0.5	4467.7	0.3
Yilan rice	7013.3	-747.3	0.39	0.45	3155.9	0.3
Jiansanjiang798	10093.4	-425.1	0.59	0.6	5687.8	0.3
Jiamusi rice	6103.7	-741.7	0.45	0.4	2538.9	0.2
Xingyuan colorful rice	8334.8	-438.6	0.40	0.5	3934.2	0.3
Long grain fragrant	11641.1	-612.0	0.49	0.5	6373.9	0.3
Volcanic rocks nutritional rice	9640.0	-532.4	0.40	0.5	4927.3	0.3
Tailai rice	9118.5	-363.6	0.441	0.5	4506.5	0.3
Qiqi Har rice	9769.6	-466.7	0.50	0.5	5328.8	0.3

Table 2: TPA Results.

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Chemical composition analysis of rice flours

Water, ash, protein and fat contents were determined according to the AACC International 2002 methods (methods 44-01.01, 08-01.01, 46-09.01, 30-10.01, respectively). Carbohydrates was determined by difference as carbohydrates=100-(water+protein, fat and ash). Amylose content was determined according to the AACC 2002 International method 61-03.01.

Sensory evaluation of rice

Texture index was measured by sensory method. The rice was steamed with rice cooker by a cup of sample and 2 cups of water for 30 minutes. Sensory attributes of the cooked rice sample were evaluated using a descriptive analysis method. Seven female and three male subjects who were non-trained panelists from the College of Food Technology at Harbin University of Commerce (Harbin, China) participated in the sensory evaluation. Grading rules are shown in Table 1. The evaluation was done in normal light conditions at room temperature. Samples were in the same container and coded randomly with 3-digit numbers (Table 1).

TPA analysis of rice

Texture Profile Analysis (TPA) was performed using a texture analyzer (TA-XT2i; Stable Microsystems, Surrey, UK) with a 5 kg load cell, fitted with a 50 mm diameter cylinder aluminum probe. Hardness, adhesiveness, springiness, cohesiveness and resilience were measured for all samples. Tweezers were used to pick up 10 grains of steamed rice from the middle of the container, and evenly placed them individually in the center of the platform area of round layer. Compression force was measured during the test, the pretest speed was 2.0 m/s, test speed 1.0 m/s, and after test speed was 1.0 m/s, a compression ratio 30% was used and the trigger force set to 1 g (Table 2).

Data processing analysis

Data analysis was conducted using the software program of Statistical Package for the Social Sciences (SPSS) and Excel 2003 17.0, in order to assess significant differences among samples. Differences were considered significant when $p<0.05$.

Results and Discussion

Chemical composition of different regions rice

Amylose and protein not only are the most important nutrients of rice, but also are the significance factors affecting its qualities [11,12]. Chemical composition from different regions rice is shown in Figure 1. Results showed that in general rice from different regions had different moisture, fat, protein, ash, amylose and carbohydrates contents. Protein content ranged between 5.7~8.2%. Sample number 7, 6, 18, 14 and 8 had protein content higher than 8%. Fat content ranged between 0.3% and 1.1%, the lowest one was for sample 4 while the highest one was sample 6. Carbohydrate content ranged from 76.4% to 79.2%. The biggest one was for sample 12 and the smallest one was sample 6.

Amylose content of sample 5 Qiuran rice was the lowest of 14.93% and the highest level was sample16 of 23.81%. Difference of rice moisture content was smaller, between 12% and 14%, which is beneficial for rice storage. From the point of coefficient of variation, fat, amylose and protein content was larger, it could be explained that though these composition in the total proportion did not take the most, they were likely to affect the eating and processing quality of rice.

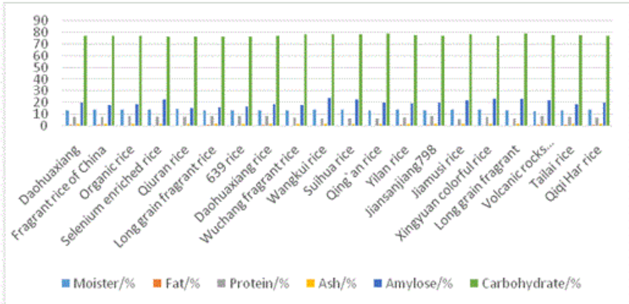

Figure 1: Chemical composition (%) of different regions rice and mathematical analysis.

Difference analysis of rice texture characteristics

As shown in Figure 2 the texture indicators of twenty kinds of cooking rice had no significant difference. There were five kinds of rice whose total score was beyond 24 points respectively which sample numbers are 9, 13, 14, 5 and 8. The highest one was sample 13, whose taste was the best. There were fourteen kinds of rice whose total score was between 21 and 24 points, including sample number 20, 2, 6, 16, 3, 10, 4 and 1. From the point of view of several sensory indicators, their texture was better, and only 1sample 1 scored about 20 points whose taste was poor. These differences may be due to genetic differences, breeding method, variety, growth environment, geographical conditions and cultivation [13]. So in order to describe the relationship between taste indexes and major chemical components of different regions rice scientifically and accurately, it is necessary to analysis the differences between them.

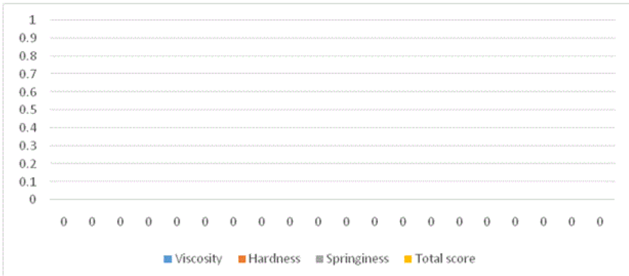

Figure 2: Comprehensive evaluation of rice texture index.

Difference analysis of rice TPA

The variation range of rice hardness was from 6103.7 g to 11641.1 g, the lowest was sample 15and the highest was sample 17; the variation range of rice adhesiveness was from 363.6 gs to 1120.3 gs, the highest was sample 10 and the lowest was sample 19; the springiness change range was from 0.38 to 0.59the lowest and highest was sample 9 and 14 respectively; the cohesion change range was from 0.4 to 0.6, the lowest was sample 9, and the highest was sample 14; the gumminess change range was from 2538.9 to 6373.9, the lowest was sample 15, and the highest one was sample 17; the resilience change range was from 0.2 to 0.3, the lowest and highest resilience rice was sample 15 and 14 respectively. From the above we can conclude that hardness, gumminess and resilience of sample 15 rice were minimum ones. And even though other indicator of sample 15 did not reached minimum, it was still very small. Similarly, the hardness and gumminess of sample 17 rice and cohesion and resilience of sample 14 rice were maximum. Larger hardness illustrates the rice has tight inner structure, so its cohesiveness and gumminess is bigger, which increase elasticity and resilience of rice. Instead smaller the hardness, looser the structure among rice, gumminess and resilience also become worse, and rice also becomes relatively looser.

The correlation between chemical composition and rice taste index of different regions rice

According to the report that amylose content of rice was important factors that affect the rice texture [14]. The results showed that amylose content was negatively correlated with viscosity and total score of rice, and significantly positive correlated with rice elastic with the correlation coefficient of 0.467. It turned out that higher or lower amylose content didn't mean better sensory quality. When amylose content was too low, cooked rice was sticky, its elasticity was small and taste was poor. On the other hand when amylose content was too high, cooked rice was hard and fluffy and its taste was not very good either. When rice amylose content was 15%~20%, its quality could be up to standard grade 1 or 2, so the amylose content of superior rice should be moderately fit. From Table 3 we concluded that protein content was negatively correlated with stickiness of rice and significantly positively correlated with its springiness, a similar tendency was reported by Mohammed et al. [15]. Adipose content was positively correlated with stickiness and hardness and negatively correlated with elasticity. Ash content was negatively correlated with stickiness and total score; Moisture content was positively correlated with elasticity and negatively correlated with stickiness and hardness. Carbohydrate content was positively correlated with viscosity and negatively correlated with hardness, elasticity, and total score of rice.

Correlation analysis of chemical composition and texture characteristics of different regions rice

It is indicated that: (1) moisture content was negatively correlated with hardness, resilience, gumminess and adhesion of rice, and was positively correlated with springiness. It could be the reason that there was moisture difference between grain abdomen and back after soaking for the rice with low moisture content (<14%) which led to the volume difference and made instant cracks that was the flowering phenomenon. Starch grains come out from cracks, and rice loses elasticity and becomes tacky [16]. (2) Protein content was negatively correlated to the adhesion of rice and positively correlated with hardness, cohesiveness and gumminess of rice, and had significantly positive correlation with resilience.

Comprehensive index	Stickiness	Hardness	Springiness	Total score
Water	-0.058	-0.159	0.281	0.012
Fat	0.159	0.369	-0.127	0.083
Protein	-0.230	0.271	0.444*	0.336
Ash	-0.287	0.111	0.069	-0.336
Amylose	-0.118	0.087	0.467*	-0.387
Carbohydrate	0.310	-0.365	-0.419	-0.316

Table 3: Correlation analysis between sensory parameters and chemical composition. Note: * at 0.05 level (double side) significant correlation.

	Chemical components					
Structure characteristics	Moisture/%	Fat/%	Protein/%	Ash/%	Amylose/%	Carbohydrate/%
Hardness	-0.376	0.123	0.278	0.258	0.212	-0.121
Adhesiveness	-0.289	0.202	-0.127	-0.316	-0.141	0.010
Springiness	0.144	-0.020	0.067	0.325	-0.195	-0.121
Cohesiveness	-0.357	0.316	0.366	0.335	0.113	-0.265
Gumminess	-0.387	0.200	0.286	0.320	0.204	-0.146
Resilience	-0.428*	0.322	0.461*	0.223	0.076	-0.309

Table 4: Correlation analysis between TPA results and chemical composition. Note: * at 0.05 level (double side) significant correlation.

It might be because that higher protein content meant more closely grain structure and smaller space between the starch grains which made water absorption slow and little, so inhibited starch gelatinization and expansion, and more water and time were needed for cooking which made rice hard and loose and had low viscosity [17]. (3) The ash content of rice was negatively correlated with its adhesion, and positively correlated with hardness, springiness and other indicators, but not obvious. (4) The hardness, cohesiveness, gumminess and resilience of rice were positively correlated with its amylose content. It is due to that in the heating process of the rice starch grains rupture and amylose dissociates out from starch grains to form three-dimensional matrix structure, the starch grains embedding inside. More amylose content [18], more closely matrix structure and more difficult to be destroyed, which cause the rheological properties to worse, and hardness, cohesiveness and gumminess increasing [19] (Table 4).

Correlation analysis on rice texture characteristic and TPA index

From Table 5, viscosity value of rice taste index and adhesiveness of structure properties showed significantly positive correlation, and the correlation coefficient was 0.444, so it is visible that viscosity of rice taste index can be replaced by adhesiveness of textural characteristic. The softness of taste index showed positive correlation with not only texture characteristic hardness, but also cohesiveness. It is because that the bigger hardness the tighter inner structure rice possesses, the bigger cohesiveness it shows. Similarly, taste index elasticity and texture characteristic springiness had positive correlation as well, indicating that the springiness of texture characteristic can take the place of the one of taste index in rice. More significant correlation between elasticity of taste and gumminess of texture characteristic indicated that there was relevance between mechanical work of chewing to swallow and elasticity of taste. It was interesting that elasticity of taste was negatively correlated with hardness of texture characteristic. Total score of rice taste index and hardness, adhesion, springiness and cohesiveness of properties characteristic were positively correlated, and the biggest correlate index was adhesion, indicating that it is important factor to determine the final rice taste.

	Taste index			
Texture characteristics	Viscosity	Softness	Elasticity	Total score
Hardness	-0.264	0.273	-0.229	0.111
Adhesiveness	0.444*	-0.023	-0.059	0.276
Springiness	-0.192	0.152	0.185	0.089
Cohesiveness	-0.133	0.357	0.143	0.083
Gumminess	-0.016	0.309	0.201	0.097
Resilience	-0.063	0.350	0.116	0.146

Table 5: Correlation analysis between TPA results and sensory evaluation. Note: * at 0.05 level (double side) significant correlation.

Conclusions

There were many differences in chemical composition and texture characteristics, but few in taste of different regions rice. The correlation between rice chemical composition, and texture and sensory characteristics was that the fat, ash, amylase and protein content of different regions rice had significantly influence on its taste quality and structure characteristics. The correlation analysis on texture characteristic and taste quality of rice shows that there was little difference between themso structure features could reflect people's overall evaluation of rice taste.

Acknowledgments

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