Effect of Rice Fissure on Taste Quality of Cooked Rice

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ABSTRACT

According to the change of texture attribute of cooked-rice under different fissure rate of rice, the relationship between fissure rate of rice and taste value of cooked rice were studied using correlation analysis and path analysis methods. The data of correlation analysis showed that the influence of texture attribute was significant on taste. Fissure rate had an effect on taste through hardness, gumminess, chewiness, and springiness. The data of path analysis suggested that the direct effect of gumminess was significant on taste, and the other indicators of texture attribute had indirect effect through gumminess. A regression model was constructed based on the indicators viz fissure rate, texture attributes.

Keywords: Rough rice, fissure, texture attribute, taste value, sensory analysis

1. INTRODUCTION

Rough rice fissure occurs frequently during harvesting, drying, storage, handling and processing (Iguaz *et al.*, 2006; Cnossen *et al.*, 2003; Bautista *et al.*, 2000; Cnossen *et al.*, 2000; Li *et al.*, 1999). Since the 1920s, researchers began to pay attention to the problem of rice fissure. Researchers found that fissure was caused by stress shrinkage in kernel because of uneven distribution of the moisture of rice kernels during moisture adsorption or desorption, particularly during the high temperature drying, due to the rapid decreasing of moisture in rough rice, the degree of fissure was serious after drying (Naoto *et al.*, 2006; Jia *et al.*,2002; Yang *et al.*, 2002; Lan and Kunze, 1996). Fissure has significant effect on quality of rice, such as decrease of head rice yield and taste value of cooked-rice (Zhang *et al.,* 2005; Champagne,2004; Wang *et al.*, 2003; Zheng and Lan, 2007).

The objective of this study was to investigate relationships between fissure rate and texture attribute, as well as between texture attribute and taste result, and analyze the effect of fissure rate on rice taste using the methods of correlation analysis and path analysis methods.

2. MATERIALS AND METHODS

2.1 Rice Sample

Freshly harvested rough rice of cultivar 'Dong Nong 423' (Northeast Agricultural University Farm, Harbin, China) was selected for this study. Raw rice was dried by natural drying to the final moisture content of 14.5 % (w.b.). The dried raw rice sample was milled to 90 % of initial weight using auto-milling detector (SY95-RAE4, Ssang Yong Machine Ind. Co. Ltd., Korea). Rice sample was divided into 4 portions according to fissure rates, *viz.* 0.33 % (initial fissure rate), 25 %, 50 % and 75 %, which were obtained by artificial preparation. Each portion was pre-weighed into 2000 g and divided evenly into 4 groups for the repeat test.

2.2 Cooked Rice Preparation and Determination

Each rice sample was prepared into cooked rice. Each of the rice samples (500 g) were cooked in household steam rice cookers (National, SR_W10FN, Japan) with 1.45:1 (v/v) water-to-rice ratio. Twenty minutes after the cooker switched from cook to warm setting, the cooked rice within 1 cm of the top, bottom, and side of the inner pan in the rice cooker was discarded and the middle portion was transferred to a bowl. Cooked rice was placed in a bowl and stirred gently five times with a fork using an up and down motion, then held for 5 min at room temperature. Stirring and holding procedures of cooked rice were repeated twice. The cooked rice was then cooled and portioned for taste evaluation. Texture attribute of cooked rice was measured using Texture Analyzer (TA-XT plus, Stable Micro Systems Ltd., UK). Twelve professionally trained panelists, employed by the National Rice Quality Test Center, Harbin, China, developed a sensory profile of cooked rice samples according to the (rice sensory standard from Department of Agricultural, P.R China). During panel tests, the cooked rice taste was evaluated in terms of flavor (15 points), appearance (15 points), tooth sense (60 points) and texture of the cool cooked rice (10 points). The appearance attributes examined were color, glossiness, intactness of grains and plumpness. Eight attributes to evaluate cooked rice flavor included boiled egg white, puffed corn, raw rice, wet cardboard, hay-like, metallic, sweet taste, and bitter taste. The panelists adequately described the texture profile of cooked rice and identified nine tooth sense attributes: adhesiveness to lips, hardness, cohesiveness of mass after three chews, cohesiveness of mass after eight chews, roughness of mass, toothpull, particle size, toothpack, and loose particles. Texture attributes included the degree of agglomeration, adhesiveness and roughness. Park and Kim (2001) described the definitions and degree of those attributes and test procedure for measuring cook-rice taste.

2.3 Statistical Analysis

Fissure rate of rice (x1), and texture attributes of cooked rice, viz. hardness (x2), adhesiveness (x3), springiness (x4), cohesiveness (x5), gumminess (x6), and chewiness (x7) were considered as independent variables, and taste result of cooked rice (y) was regarded as dependent variable. Programs of Microsoft Office Excel 2003 (Microsoft Corp., USA) and statistics software SAS (V12.01, SAS Institute Inc., USA) were used to analyze data.

3. RESULTS AND DISCUSSION

Texture attribute and taste result in different fissure rates are shown in Table 1.

3.1 Significance Analysis

According to the results in Table 1, no significant difference was found for adhesiveness, cohesiveness and resilience. Therefore, fissure rates had no effect on the three indicators of texture attribute, while the differences were significant for other indicators of texture attribute, *viz.* hardness, springiness, gumminess and chewiness. For the 4 indicators, the minimum happened at 0.33 % level of fissure rate. There were not distinct differences for springiness and gumminess between 25 % and 50 % levels of fissure rate, while the differences were significant in 75 % level of fissure rate. At the fissure level of 25 %, hardness and chewiness increased significantly, while there were no changes between 50 % and 75 % levels of fissure rate. Taste results decreased significantly with increasing fissure rate.

Table 1. Texture attribute and taste result in different fissure rates

Fissure rate, %	0.33	25	50	75
Hardness, g	4547 ± 397^{a}	5150 ± 958^{ab}	5927 ± 296^{b}	6196 ± 953^{b}
Adhesiveness, g×sec	-363±25	-343±58	-353±58	-326±66
Springiness	0.28 ± 0.03^{a}	0.30 ± 0.02^{ab}	0.32 ± 0.03^{ab}	0.32 ± 0.01^{b}
Cohesiveness	0.39±0.02	0.39±0.02	0.41±0.01	0.41±0.02
Gumminess	1787 ± 212^{a}	2045 ± 477^{ab}	2424 ± 190^{ab}	2547 ± 630^{b}
Chewiness	503 ± 88^{a}	618 ± 173^{ab}	770 ± 116^{b}	831 ± 236^{b}
Taste result	68.0 ± 2.0^{a}	63.5 ± 5.6^{ab}	58.9 ± 2.2^{bc}	57.6 ± 1.5^{c}

The same superscript in the same row suggested that there was no significant difference between two fissure rates at 5 % significance level.

3.2 Correlation Analysis

To determine the effect of fissure rate on taste quality of rice, the correlation analysis on the fissure rate, texture attribute and taste value were analyzed, and the results were shown in Table 2.

3.2.1 Correlation Analysis Among Texture Attributes

According to the results in Table 2, it is shown that there were significant positive influences among other indicators, *viz.* hardness, springiness, cohesiveness, gumminess, and chewiness, except for adhesiveness, at significance level of P≤0.05.

Table 2. Significance levels (top right) and correlation coefficients (bottom left) among every variable

	x1	x2	x3	x4	x5	x6	x7	y
x1	1	0.0039	0.3893	0.0103	0.1539	0.0091	0.0050	0.0002
x2	0.6785**	1	0.5036	0.0025	0	0	0	0.0036
x3	0.2310	0.1805	1	0.7325	0.6532	0.4677	0.6057	0.6617
x4	0.6209*	0.7017**	-0.0928	1	0.0012	0.0018	0.0001	0.0292
x5	0.3737	0.8551**	0.1218	0.7348**	1	0	0	0.0990
x6	0.6287**	0.9941**	0.1957	0.7153**	0.9015**	1	0	0.0089
x7	0.6649**	0.9736**	0.1397	0.8282**	0.9001**	0.9820**	1	0.0090
y	-0.8053**	-0.6817**	0.1187	-0.5444*	-0.4270	-0.6302**	-0.6297**	1

**=Significance level P≤ 0.01; *=Significance level P≤ 0.05

3.2.2 Correlation Analysis between Textures Attributes and Taste Value

Table 2 shows the relationship between texture attributes and taste result. No significant effect for the adhesiveness (x3) and cohesiveness (x5) of texture attribute was found on cooked-rice taste value, while the significant effect exists for the other indicators of texture attribute. The influence of hardness (x2), gumminess (x6), and chewiness (x7) was extremely distinct on taste result (P≤0.01), springiness had significant effect (P≤0.05), and correlation coefficients were all negative.

3.3 Path Analysis between Textures Attributes and Taste Value

Correlation coefficient shows only degree of correlation between independent and dependent variable, while the composition and source of correlation can not be explained and analyzed. In order to study the influential mechanism of fissure rate of rice on taste value of cooked-rice, it is necessary to analyze the relationship between independent and dependent variables using path analysis method. The analysis results are listed in Table 3.

Table 3. Path analysis between taste result of cooked rice and each indicator

Factor	Direct path analysis	→x1	→x2	→x3	→x4	→x5	→x6	→x7
x1	-0.6707		1.5334	0.0833	-0.7565	0.4104	-3.7798	3.2039
x2	2.2599	-0.4551		0.0651	-0.8550	0.9390	-5.9767	4.6915
x3	0.3606	-0.1550	0.4078		0.1131	0.1338	-1.1763	0.6734
x4	-1.2185	-0.4164	1.5857	-0.0335		0.8070	-4.3007	3.9906
x5	1.0982	-0.2506	1.9323	0.0439	-0.8953		-5.4201	4.3372
x6	-6.0121	-0.4217	2.2466	0.0706	-0.8716	0.9901		4.7318
x7	4.8186	-0.4459	2.2003	0.0504	-1.0091	0.9885	-5.9037	

Based on path analysis theory, correlation coefficient can be decomposed into direct and indirect correlation coefficients. Absolute value of path coefficient denotes influential degree, and the larger the absolute value is, the more significant the influence between two variables is. While the positive-negative sign of path coefficient represents influential direction between two variables including positive value denoting positive correlation, and negative denoting negative correlation (Li *et al.*, 2005).The results from table 3 show the path coefficient between taste result of cooked rice and each indicator. The direct impact factors of texture attribute on taste result were shown in turn: gumminess (x6) > chewiness (x7) > hardness (x2) > springiness (x4) > cohesiveness (x5) > adhesiveness (x3). Apart from direct path coefficient, path analysis also includes indirect path coefficient that secondary factor impacts on taste result based on main factor. If indirect path coefficient is larger than that of direct, indirect path coefficient dominates main impact on correlation. According to the results in Table 3, it can be shown that the influence of direct path correlation of gumminess on taste result was negative, and the absolute value of direct coefficient was higher than that of indirect path coefficient. Therefore, direct effect was more significant than indirect effect, and gumminess was correlated negatively with taste result. The impacts of direct path coefficients for the other indicators of texture attribute on taste result were less than that of indirect path coefficients through gumminess. The negative indirect path coefficients showed that these indicators were correlated negatively with taste result. The indirect path coefficients of adhesiveness through the other indicators were very little, due to the insignificant influence of adhesiveness on the other indicators of texture attribute.

3.4 Relationship between Fissure Rate and Taste Value

According to the results in 3.2.2 section, taste value of cooked rice was significantly correlated with texture attribute. Furthermore, the significant effect of fissure rate on hardness (x2), gumminess (x6), chewiness (x7), and springiness (x4)was found . These indicators were positively correlated with fissure rate, while negatively correlated with taste result, so it can be deduced that fissure rate had significant impact on taste result, and the correlation was negative. The results in Table 3 show that direct path coefficient between fissure rate and taste result was -0.6707, and indirect path coefficient through gumminess was -3.7798, so indirect effect was dominant, and fissure rate was correlated negatively with taste result. Direct path coefficient obtained least value in all path coefficients between fissure rate and taste result, that is, the direct effect was least significant. Based on above analysis, it can be deduced that fissure rate had significant effect on taste result through indirect effect of texture attribute indicators. Therefore, except for the cohesiveness and adhesiveness due to the insignificant effect on taste result, the other indicators with high confidence were used to fit a regression equation as follows. Fissure rate (x1), hardness (x2), springiness (x4), gumminess (x6), and chewiness (x7) were selected as independent variables, taste result of cooked rice (y) as dependent variable. Stepwise regression analysis method in SAS software was used to construct regression equation, as follows:

$$y = 159.0438 + 0.0651\ x1 - 0.0195\ x2 - 131.4875\ x4 + 0.0371\ x6 + 0.0501\ x7 \qquad (1)$$

For this regression equation, significance level was $P=0.0057$ and correlation coefficient resulted in $r=0.9058$, so the regression model fitted well. The verifiable experiments show the validity.

In this study, appearance quality (fissure rate) and texture attribute (hardness, springiness, gumminess, and chewiness) were selected as independent variables of regression model of taste result. Compared to previous study (Zheng, 1999), these independent variables of regression model not needed to be measured by complicated chemical experiments, and the values were easily obtained. This model not only quantitatively analyzed the correlation among fissure rate of rice, indicators of texture attribute and taste result, but also predicted taste result of cooked rice, as well as offered the orientation for the classification of rice.

4. CONCLUSIONS

No significant effect of the rice fissure rates was observed on the adhesiveness, cohesiveness of texture attribute of cooked-rice, and the rice fissure rate had significant impact with different levels on hardness, springiness, gumminess and chewiness. The rice fissure caused the taste quality of cooked rice decrease through the texture attribute including hardness, springiness, gumminess, chewiness and resilience. The taste value can be predicted according to the fissure rate and texture attribute including hardness, springiness, gumminess and chewiness.

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