



## CORRELATION BETWEEN MOISTURE CONTENT OF MILLED RICE AND TEXTURE OF COOKED RICE AS EVALUATED BY SENSORY TEST

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### ABSTRACT

Rice (*Oryza sativa* L.) holds a high place among the world's top agricultural products for its economic and social importance. The prices of milled rice vary by the moisture contents of the rice while the retail prices paid by consumers depend upon the rice eating quality. The correlation between the moisture content of milled rice and the texture of cooked rice as evaluated by sensory tests is the main topic of this research. Five types of Thai rice from the rice quality improvement plant (C.P. Rice Co., Ltd.) were used in the study. The moisture contents of the five types of milled rice were measured with a rice moisture tester, while the texture of cooked rice was evaluated by a trained sensory panel of five females and five males. The 10-member panelists evaluated the cooked rice on the scale of 1 to 5 along the four texture indices of hardness, stickiness, adhesiveness and dryness. It is found that texture of cooked rice is unaffected by the moisture content as the coefficients of determination ( $R^2$ ) range from 0.163 to 0.187. However, the correlations between pairs of the four texture indices are found to be very high with  $R^2$  ranging from 0.935 to 0.970. The study shows any one index value (e.g., dryness) can be substituted in the linear equations containing such an index value (i.e., dryness) as a component to determine another (second) texture index value. The second index value is subsequently substituted in any linear equations with it as a component to determine the third index value. The procedure is repeated with the third value for the fourth index value. The practice could certainly reduce the time usually required of the rice quality improvement plant for rice quality inspection.

### INTRODUCTION

Rice is Thailand's most important agricultural produce grown to feed both domestic and international consumers. The wholesale prices (i.e., prices paid to rice mills) of milled rice vary by the moisture contents of the rice, while the retail prices (i.e., prices paid by consumers) depend upon the rice eating quality, a practice that has been adopted by many including the rice quality improvement plant in the study.

Sensory evaluation is a complex and time-consuming task, whereas the measurement of moisture content of milled rice with a rice moisture tester is much less complex. This study hypothesizes that the moisture content of milled rice and the texture of cooked rice is correlated. In addition, the correlations between pairs of the four texture indices of cooked rice of certain rice varieties were reported [1]. The

relationships between chemical components (i.e., amylose, protein and lipid) of milled rice and textural sensory attributes were investigated in the previous research [2]. Nonetheless, neither research studies discussed the linear equations of the correlations of the interested parameters: hardness, stickiness, adhesiveness and dryness.

This research aims to establish the linear equations from the correlations between moisture content and the four sensory texture indices and from those between pairs of the four texture indices. The linear equations are then employed to determine the effect of the moisture content of milled rice on the texture of cooked rice.

### MATERIALS AND METHODS

#### Determination of Criteria of Texture Indices

Samples of five different types of milled rice, which were most representative of varying textures, were prepared by the quality control section of the factory and delivered to the NIRS Research Center for Agricultural Product and Food at King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. In this research the texture indices of rice encompass adhesiveness, hardness, stickiness and dryness, all of which have been used by the rice quality improvement plant for quality evaluation.

The five types of the rice samples were cooked according to the water to rice ratios suggested by the plant. A team of panelists of 5 males and 5 females were served with the five types of cooked rice samples each. The panelists would confer among one another before collectively deciding on the score to give to each of the four texture indices of the cooked rice. The scorings of the adhesiveness, hardness and dryness indices are on the scale of 1 – 5, where 1 denotes the minimum level and 5 the maximum level, whereas the criteria are reversed for the stickiness index where 1 is for the maximum level while 5 for the minimum level. The scores given by the panelists are only in integers (i.e., 1, 2, 3, 4, or 5).

#### The Training of Sensory Panelists

The 10-member panelists were given multiple training sessions to acquaint them with the scoring criteria of rice sensory evaluation. Each panelist was served with one scoop of cooked rice of all the five rice types. The panelists were trained to assess the rice adhesiveness by either shaking small lid-covered plastic containers containing cooked rice or gently scraping the top surface of the cooked rice samples with a small plastic spoon or both. For the hardness and stickiness, the panelists were asked to chew all

five types of cooked rice and then explain in short phrases as to the hardness (e.g., extremely hard, hard, etc.) and the stickiness (e.g., extremely sticky, sticky, etc.). The hardness and stickiness criteria were used in the subsequent scorings in the experimental stage. In addition, the panelists were trained to decide on the dryness by visually observing the moistness of the cooked rice.

Two replicates of cooked rice for each of the five rice types were used in each sensory evaluation training session. The training session continued until the 10 participating panelists were skilled at the quality assessment. It should be noted that before each subsequent assessment, the panelists would be served with drinking water to wash out the aftertaste and rice residues from the previous assessment inside their mouths, and that the cooked rice samples (i.e., five samples) in the training sessions were of different lots from those (i.e., 250 samples) in the experimentation.

### **Rice Samples**

The 250 samples of Thai milled rice were received from the same rice quality improvement plant (C.P. Rice Co., Ltd., Thailand). The rice samples were randomly garnered from three locations inside the factory premises, i.e., from the raw material receiving station, behind the color sorter machine, and under the storage bin. The three locations were selected for sample collection since they are the sites at which the rice samples are typically collected for the internal quality inspection. The samples of milled rice were of parboiled rice, white rice, new Jasmine rice (harvested in 2012), and aged Jasmine rice (harvested in 2006 or during 2007-2011) types of 51, 23, 12, and 164 samples, respectively. The weight of each milled rice sample was approximately 200 g, which was retained in a plastic zipper bag until experimentation.

### **Moisture Content Measurement**

The moisture content of milled rice was measured by the moisture content tester (KETT model Riceter F-521, Japan). Three replicates of each sample were measured and the measurements were then averaged. Approximately 2 g of milled rice were used per replicate.

### **Cooked Rice Preparation**

Home electronic rice cookers (RC-10 MM, Toshiba, Thailand) were used to cook 250 samples of five types of milled rice with 200g for each rice sample. The five rice types were cooked according to the different water to rice ratios recommended by the plant, i.e., 2.5:1 for parboiled rice; 1.6:1 for white rice; 1:1 for new Jasmine rice harvested in 2012; and 1.2:1 and 1.4:1 respectively for aged Jasmine rice harvested in 2007-2011 and in 2006. After the rice was fully cooked and the rice cooker automatically switched to the warm mode, the cooked rice was gently and thoroughly mixed using a plastic ladle before transferring to the small closed-lid plastic containers for sensory evaluation. The cooked rice samples were then presented to the sensory panelists for evaluation.

### **Sensory Evaluation**

The trained sensory panelists of 5 males and 5 females were asked to separately give a score on the scale of 1 – 5 to each of the four texture indices, where 1 denotes the minimum level and 5 the maximum level for adhesiveness, hardness, and dryness. However, the criteria of the scores are reversed for the stickiness index. The scores of the

texture indices given by the panelists were allowed to contain only one decimal point. The evaluation of 250 cooked rice samples followed the same procedures as that in the training stage. Prior to panelists' tasting, each sample was assigned a random 3-digit number. Moreover, before each subsequent evaluation, the panelists were served with drinking water to wash out the aftertaste or rice residues from the previous assessment inside their mouths. Each day 24–30 samples (out of a total of 250) of cooked rice were served for sensory test, and prior to sensory evaluation of each day, the panelists are re-trained on the sensory evaluation criteria.

### **Statistical Analysis**

The relationships between the moisture content of milled rice and texture indices of cooked rice and between pairs of the texture indices were computed using the linear regression function of the Microsoft Excel application program. The coefficients of determination ( $R^2$ ) were used in determination of the correlations with the confident level of 95%.

## **RESULTS AND DISCUSSION**

### **Correlations of Moisture Content between Milled Rice and Texture of Cooked Rice and between Pairs of the Texture Indices**

The linear equations of the relationships between moisture content of milled rice and texture of cooked rice and between pairs of the texture indices are shown in Table 1. The coefficients of determination ( $R^2$ ) between the moisture content of milled rice and the texture indices were from 0.163 to 0.187. This indicates that the moisture content of milled rice has no effect on the texture of cooked rice.  $R^2$  of pairs of the texture indices were between 0.935 and 0.970. Previous research studies reported lower correlation values of pairs of the texture indices than in this research [1]. The high  $R^2$  values point to the fact that knowledge of any one value of the four texture indices makes possible the calculation of the remaining indices by linear equations. That is, any one index value can be substituted in the linear equations containing such an index value as a component to determine another (second) texture index value. The second index value is subsequently substituted in any linear equations with it as a component to determine the third index value. The procedure is repeated with the third value for the fourth index value.

Of the four indices under the study, dryness evaluation can be readily performed merely by visual observation. As such, it is advisable that dryness evaluation be selected to find the starting texture index value for subsequent determination of the three remaining texture index values by substituting the obtained dryness index value and then other subsequent index values in the linear equations.

The linear equations of adhesiveness with stickiness (AN with SN) and hardness with dryness (HN with DN) show a positive slope, indicating positive correlations of the two pairs. On the other hand, the linear equations of adhesiveness with hardness (AN with HN), adhesiveness with dryness (AN with DN), hardness with stickiness (HN with SN), and dryness with stickiness (DN with SN) display a negative slope, thereby indicating that the relationships of the four pairs are inversely correlated.

## **CONCLUSION**



The moisture content is found to have no effect on the eating quality of cooked rice. The relationships of pairs of the four texture indices of cooked rice are highly, positively correlated ( $R^2=0.935$  to  $0.970$ ). The study reveals that any one index value (e.g., dryness) can be substituted in the linear equations containing such an index value (i.e., dryness) as a component to determine another (second) texture index value. The second index value is subsequently substituted in any linear equations with it as a component to determine the third index value. The procedure is repeated with the third value for the fourth index value. Of the four indices, dryness evaluation by visual observation is the easiest to perform and thereby should be undertaken to derive the starting index value for the subsequent determination of the three remaining indices, i.e., hardness, stickiness, and adhesiveness. Following the practice certainly reduces the time normally required of the rice quality improvement plant for rice quality inspection.

Table 1: Linear equations of the relationships between moisture content of milled rice and the texture of cooked rice and between pairs of the texture indices.

Parameters (x with y)	Equations	R <sup>2</sup>
MC with AN	$y = 1.232x - 14.225$	0.187
MC with HN	$y = -1.023x + 17.306$	0.163
MC with DN	$y = -1.098x + 18.335$	0.182
MC with SN	$y = 1.205x - 13.797$	0.183
AN with HN	$y = -0.863x + 5.577$	0.941
AN with DN	$y = -0.885x + 5.643$	0.962
AN with SN	$y = 0.974x + 0.133$	0.970
HN with DN	$y = 0.994x + 0.031$	0.961
HN with SN	$y = -1.075x + 6.248$	0.935
DN with SN	$y = -1.072x + 6.249$	0.956

MC - Moisture content  
AN - Adhesiveness  
HN - Hardness  
DN - Dryness  
SN - Stickiness

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