77
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DETECTING RICE QUALITY AS INFLUENCED BY HULLING USING VISIBLE AND NEAR-INFRARED SPECTROSCOPY

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ABSTRACT

Visible and near-infrared (VIS/NIR) spectroscopy calibration models for rice taste evaluation were developed Sakha, 101 short-grain rice variety. The best performance calibration model was obtained from original spectra of whole grain milled rice using multiple linear regression (MLR) analysis. The correlation coefficient (R^2) and the standard error of prediction (SEP) of the validation set was 0.83 and 0.31, respectively for estimated taste value. Near-infrared transmission (NIRT) spectroscopy was used in an attempt to predict moisture content, protein content and amylose content from un-dried whole grain rough and milled rice spectra. Using partial least squares calibration models obtained from un-dried whole grain rough and milled rice spectra, the coefficient of determination (R^2) and the standard error of prediction (SEP) of the validation set were R^2 = 0.96 and SEP = 0.46 for rough rice moisture content, R^2 = 0.82 and SEP = 0.31 for brown rice protein content, R^2 = 0.87 and SEP = 0.29 for milled rice protein content, and R^2 = 0.04 and SEP = 0.25 for milled rice amylose content. The results of the validation indicated that NIRT could be used to determine moisture content and protein content but not the amylose content. Thus, NIRT technology may be used to classify un-dried rough rice into qualitative groups such as high protein content rice and low protein content rice upon arrival at a rice-drying facility after harvesting. The results also indicated that VIS/NIR technology could be used for classifying rice samples into qualitative groups, such as poor taste, better taste and the best taste. However, taste of rice and its acceptability need to be considered to adopt lower degree of milling. A predicted equation was obtained for rice taste value depending on some physicochemical composition such as protein, amylose, moisture content, fat acid and taste value from the experiment data. According to the principle of the taste analyzer, rice taste value may be directly calculated with the content of the compositions measured at laboratory.

INTRODUCTION

The most important quality of any food is taste, especially for consumers. Physicochemical properties of rice can be measured using many different methods. For example, near-infrared (NIR) spectroscopy has been used to measure the chemical composition of grain, including such constituents as moisture, protein and amylose, with high accuracy (**Natsuga *et al* 1993 and Delwiche *et al* 1996**). Even though physicochemical properties of rice can be measured, it has been difficult to develop an instrument that would substitute for the sensory panel.

Near-infrared transmission (NIRT) spectroscopy and a calibration modeling method of partial least squares (PLS) have recently been introduced. NIR technology is widely used for assessing grain quality; however, a method for assessing the quality of un-dried whole grain by NIR technology has not yet been established. Milled rice (i.e., rice

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from which the hull, bran layer, and embryo have been removed) is usually used for cooking. The major chemical constituents of milled rice are moisture, protein, and starch (amylose and amylopectin). The protein content of milled rice is a very important quality item, especially in East Asian and African countries, where people eat short-grain, non-waxy rice **(Shibuya, 1990)**.

Recently, there has been a need in rice drying facilities for an accurate method to measure not only the moisture content but also the protein content of un-dried rough rice in order to grade the rice according to quality at the receiving pit. Recent studies have demonstrated that NIR spectroscopy can be used to measure chemical constituents, texture and taste of rice. **Natsuga *et al* (1992)** reported on the precision and accuracy of NIR in determining moisture content and protein content of ground brown rice and ground milled rice. **Suzuki *et al* (1996)** discussed factors affecting the accuracy of analysis of protein in ground brown rice using NIR. **Li and Shaw (1997)** developed a calibration model to determine the fat acidity of rough rice by NIR. **Chen *et al* (1997)** developed visible/NIR calibration models to quantify the surface lipid content of milled rice. **Delwiche *et al* (1996)** measured quality characteristics of whole-grain milled rice by NIR. **Windham *et al* (1997)** used NIR analysis of whole-grain milled rice to predict texture quality of the rice when cooked. **Kawamura *et al* (1997)** attempted to assess the taste evaluation of rice using NIR. It has been difficult to determine un-dried rough rice constituent content using NIR. Therefore, next step in NIR technology development is to apply the technology to un-dried whole-grain rough rice as affected by hulling. On the other hand, milling is a process in which the outer layer of brown rice removes and improves its translucency and customer preference. Rice milling is a combination of several unit operations to convert paddy into well-milled silky-white rice, which has superior cooking quality attributes **(Roberts, 1979)**. The majority of the consumers prefer well-milled white rice with little or no bran remaining on the endosperm. The proteins, fats, vitamins, and minerals are concentrated in the germ and outer layer of the starchy endosperm **(Itani *et al* 2002)** and these are removed by the milling operation, thus reducing the nutritive value of the rice. Rice milling (polishing) and cooking are most energy intensive processes. The degree of milling varies from region to region, which affects the head rice recovery, rice quality and energy consumption in rice processing. The quality of rice has become more important than the quantity in these days of satiation. According to the change of the propensity to rice consumption, the objective, exact and rapid methods for quality evaluation of rice are required to remote the production of high quality rice and fair trade. In this study, the performance of a partial least square (PLS) calibration model developed using NIR and visible transmittance was examined in order to improve the accuracy of the calibration model for amylose determination. Thus, the eating quality of cooked rice and the methods of its evaluation are of paramount importance in view of the consumer preference for specific textural attributes. The eating quality of cooked rice are commonly determined by trained panelists in terms of hardness (tenderness), stickiness (cohesiveness), and acceptability (degree of preference or palatability) using arbitrarily selected hedonic scales **(Sitakalin and Meullenet 2000)**.

Taste is an important index to evaluate the quality of rice. At present the experts fuzzy assess method is used to assess the rice taste, which is opt to be influenced by the personal subjective mind, experiment condition. Therefore, its result lacks the objectivity, an instrument is need to measure the taste of rice. The value of taste is the index, which shows the quality degree of the rice taste and can be obtained with the rice taste meter. The higher is the taste value, the better is rice taste quality. The quality of a rice sample is decided on the basis of its size, shape and textural features. Rice is also graded based on its degree of polish; rice grain polished to a higher degree is considered to be of greater quality.

The objective of this study was to determine the physicochemical properties that affect rice taste after hulling and develop a calibration model for evaluating the taste of rice using visible and near-infrared (VIS/NIR) spectroscopy, then to validate the accuracy of the model.

MATERIALS AND METHODS

Rice samples

Short-grain brown rice variety, Sakha 101 was selected from commercial releases from Kafr-Elsheikh governorate, Egypt for this study. This kind of rice is the most preferable and eatable variety all over Egypt **(Agric. Res. Center, 2006)**. The brown rice samples (at least 3 kg per sample) were milled with a commercial friction mill (model MCM-250, Satake Engineering, Tokyo, Japan). Each un-dried rough rice sample was divided into two parts. One part of the un-dried rough rice sample was hulled in a huller to obtain an un-dried brown rice sample (500 g/sample), and the other part was dried under constant conditions in a test dryer (model TDR-48C, Satake Engineering, Tokyo, Japan) to obtain a dried rough rice sample (500 g/sample) and then hulled in the huller to obtain a brown rice sample (500 g/sample). All moisture contents of rough rice samples were determined on wet basis. The sample processing, experimental, and data analyzing procedures are shown in **Fig. (1)**. The samples were hulled and milled using SATAKE milling machine (SB10D, SATAKE, Japan) located at Rice Mechanization Center, Meet Eldeeba, Kafr Elsheikh Governorate. A spinning cup was used for all sample varieties, i.e., ground brown rice, whole grain brown rice, ground milled rice, and whole grain milled rice, from each sample. Grinding (20 g per each brown rice and white rice) was accomplished with a home use Sanyo Food Processing machine (SKM 1580E, SANYO Electric Co. Ltd, Japan) equipped with a three mesh screen.

Before calibration and validation, the samples were randomly divided into two groups. The calibration and validation sets had 50 samples each. Two calibration modeling methods, multiple linear regression (MLR) with forward selection method and partial least squares (PLS), were applied to the original spectra and their second derivative spectra. Gap and segment size for the second derivative spectra were 10 nm and 20 nm, respectively.

Physicochemical properties

Physicochemical properties were determined for the milled rice samples as follow:

1- Moisture content was determined according to **ASAE Standards (2005)** by standard method; about 10 g of whole grain rice sample was placed in a forced air oven at 105°C for 24 h and moisture was computed on a wet basis.
2- Amylose content (apparent amylose content) measurements were performed with an auto-analyzer (LFRA Auto-analyzer, located at Rice crop laboratory, Food Technology Research Institute, Giza, Egypt). The milled rice samples (used for detecting amylose content) were grounded with a home use Sanyo Food Processing machine (SKM 1580E, SANYO Electric Co. Ltd, Japan) equipped with a three mesh screen.
3- The protein content was measured on an NIR spectrometer (Hunter lab D25L, USA), and calculated on a dry basis. Other method to measure the protein content was Kjeldahl method (both are located at Rice Crop Laboratory, Food Technology Research Institute, Giza, Egypt) and calculated on dry basis.
4- Free fat acidity value was determined by the AACC (American Association of Cereal Chemists) rapid method at Rice Crop Laboratory, Food Technology Research Institute, Giza, Egypt.
5- Whiteness, saturation, and translucency were measured on a whiteness meter (Kett Electric Laboratory C-100, Tokyo, Japan), a color difference meter (Canon Camera, Osaka, Japan) and a rice meter (QS-101D, Riken Instrument, Tokyo, Japan), respectively.
6- The texture and viscosity were defined by the first peak area of the texture profile measured on a texture-meter (Texture HP 1047A, USA) located at Rice Crop Laboratory, Food Technology Research Institute, Giza, Egypt. This calculated value was usually associated with the hardness of cooked rice.

Sensory test

Five sensory tests were used in this study such as; appearance, aroma, hardness, cohesiveness (or stickiness), and overall flavor of cooked rice (acceptability). The term hardness refers to the degree of the resistance of cooked rice to deformation during chewing whereas the stickiness implies the degree of the tendency to adhere to and pack between contacting surfaces. The acceptability level indicates the individual preference to the cooked rice samples based on manifestation of eating quality without any obligations. The sensory test was conducted once every two days and always started at 12:00 P.M. Cooking rice was accomplished with three electric rice cookers (RC-256P, Toshiba, Tokyo, Japan) for one test located at Food Technology Research Institute, Rice Crop Laboratory. The cooking procedures were the same for all samples; washing 1 kg milled rice for 5 min, rinsing it four times, adding about 1.5 litter of water, soaking it for 2 h, heating it for half an hour, before the sensory test. Panelists were selected with gender and age balance (from employee and students) and trained for the test in advance. Panelists were divided into four panel groups (each group have 5 panelists). Panelists evaluated rice samples in the lecture room under

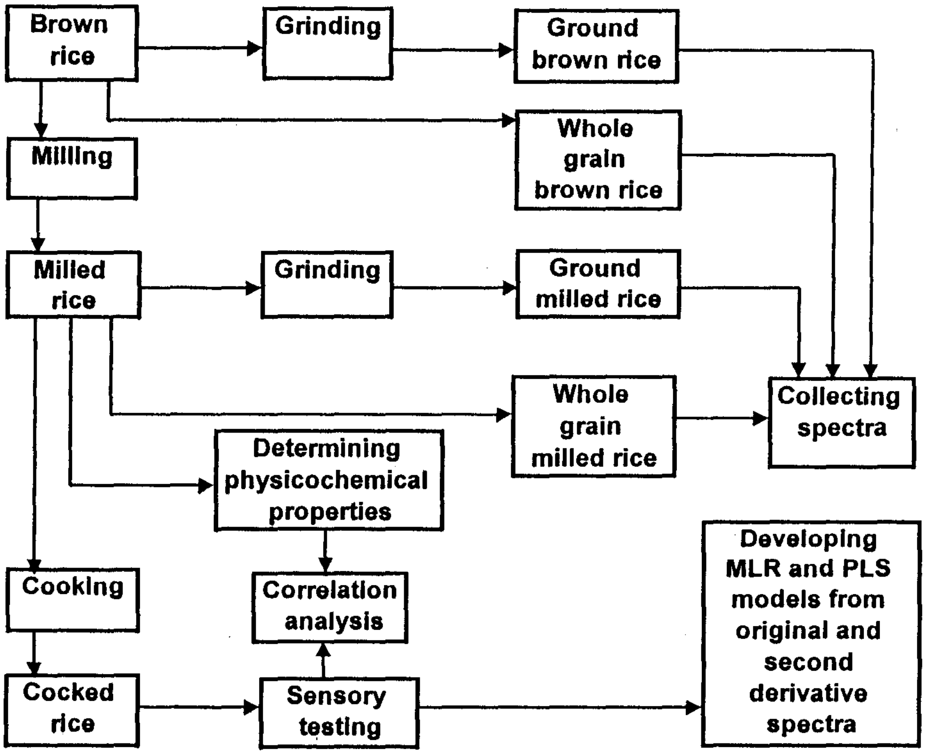

Fig. 1. Experimental sample processing and data analyzing procedures

the florescent light during the test. The sensory test was a multiple comparisons test. At the test a reference sample was labeled with a red color tape and presented to panelists with three compared samples labeled with yellow, blue, and green color tapes on a white 10 cm diameter plate. The amount of one cooked rice sample presented was about 30 g of each variety, which was enough quantity for a panelist to decide his/her evaluation. In the training sessions, the panelists were exposed to various cooked rice samples to work together as a group and discuss their sensory evaluations in order to develop a common understanding of these terms. After the training, the panelists were expected to detect and identify the intensity of various sensory attributes of cooked rice texture. The order of the three compared samples on the plate was balanced by an experimental design (Latin squares method) for each panel group. Panelists continually received one plate in each test and were asked to fill a questionere on the basis of five sensory determinations, i.e., appearance, aroma, hardness, cohesiveness, and overall flavor of cooked rice. The directions of evaluation were; poor, fair, good, very good and excellent. Numerical scores were assigned to the directions and degrees with extremely better than the reference (equaling +5), just better than the reference (equaling +4), no difference to the reference (equaling zero), worse than the reference (equaling -4) and extremely worse than the reference (equaling –5). The reference sample was always scored zero. The overall flavor was called the reference rice taste evaluation.

Using Near-Infrared Diffuse Reflectance (NIR)

NIR diffuse reflectance measurements were performed using an Oriel system by **Elbatawi and Ebaid (2006)**. The system consisted of a DC light source with the control unit, and a thermal electric cooled detector connected to an Oriel controlling/amplifying unit, which in turn was connected to a computer. A 250 W quartz tungsten halogen lamp was used to provide broadband light, which was modulated by a chopper at 60 Hz. The light was delivered to the sample through a guide cable to capture the images. The diffusely reflected light was acquired by a fiber optic detector and sent to the Oriel system where the light was dispersed according to the wavelength. The dispersed light at different wavelengths was sensed by the detector and converted into electronic signals to the computer. Used instruments were located at Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Spectra of the rice samples were recorded with a visible and near-infrared spectrometer (HP 1050, NIR Systems, USA). Near-infrared spectral analysis software was used to process the data and make the calibration models. The near-infrared transmission (NIRT) spectrometer was used to obtain NIRT spectra of un-dried rough rice, un-dried brown rice, milled rice and dried rough rice over a wavelength range of 440 to 1100 nm. Reflectance (R) readings at 2 nm increments were collected over the visible and near-infrared wavelength transformed to $\log_{10}(1/R)$, giving 1000 data points per spectrum. The loading into the sample cell was repeated ten times. One scan for each loading was saved in a computer memory. Ten scans were performed, and the data were averaged to obtain an NIRT spectrum for each sample.

RESULTS AND DISCUSSION

Moisture content

The results of PLS calibration modeling and validation statistics for moisture content are summarized in **Table (1)**. For each sample and each light path length, the correlation coefficient (R^2) of the validation set was greater than 0.90. The standard errors of prediction (SEP for validation set) for un-dried rough rice was 0.47 and it was higher than those for dried rough rice (0.31), because high-moisture rough rice had a large moisture deviation for Sakha 101 variety. The calibration model was obtained from un-dried rough rice spectra with a light path length of 25 mm. The values for R^2 and SEP were 0.96, and 0.46 respectively for un-dried rough rice. On the other hand, the values for R^2 and SEP for un-dried brown rice were 0.97, and 0.34 respectively for Sakha 101 variety. These results indicated that NIRT spectroscopy could be used to determine the moisture content of un-dried whole-grain rough rice.

A scatter plot of reference and estimated moisture content is shown in **Fig. (2)**. The calibration model was obtained from un-dried rough rice spectra with a light path length of 25 mm. The values of R^2 and SEP were 0.96 and 0.46 respectively. These results indicated that NIR spectroscopy could be used to determine the moisture content of un-dried whole grain rough rice.

Protein content

Calibration and validation statistics for brown rice protein content and milled rice protein content estimated from un-dried rough rice spectra, dried rough rice spectra and un-dried brown rice spectra are shown in **Table (2)**. The R^2 and SEP values of the un-dried rough rice calibration sets showed that the accuracy of the models with a 25-mm light path length (R^2 = 0.82 and SEP = 0.31 for brown rice, R^2 = 0.87 and SEP = 0.29 for milled rice). On the other hand, The R^2 and SEP values of the un-dried rough rice validation sets showed that the accuracy of the models with a 25-mm light path length (R^2 = 0.81 and SEP = 0.29 for brown rice, R^2 = 0.78 and SEP = 0.31 for milled rice).

Relation between reference and estimated values of the protein content of brown rice and milled rice are shown in **Figs. (3) and (4)**. Each calibration model was obtained from un-dried rough rice spectra with a light path length of 25 mm. The protein contents of brown rice and milled rice in this study were estimated from the un-dried rough rice spectra. Figures 3 and 4, however, show that NIRT technology had a reasonable ability to classify un-dried whole-grain rough rice into high and low protein content groups upon arrival at a drying facility.

Amylose content

Calibration and validation statistics for milled rice amylose content estimated from un-dried rough rice spectra, dried rough rice spectra and un-dried brown rice spectra are shown in **Table (3)**. The results of validation with un-dried rough rice and a light path length of 25 mm are shown in **Fig. (5)** (R^2 = 0.04 and SEP = 0.25). In this study, NIR could not be used to determine the milled rice amylose content from the spectra of dried brown rice and dried milled rice. The low accuracy of the estimation obtained for milled rice amylose was thought to be due to the small range of amylose contents (from 20.5% to 20.8%) in the samples and to the calibration models used for the estimation, which were obtained from un-dried rough rice spectra, dried rough rice spectra, and un-dried brown rice spectra.

Table 1. Calibration and validation statistics of moisture content for Sakha 101 variety.

	MC	Sakha 101					
		Calibration model			Validation model		
		n	R^2	SEP	n	R^2	SEP
Un-dried rough rice	20-24	50	0.96	0.46	50	0.95	0.47
Dried rough rice	12-16	50	0.93	0.28	50	0.91	0.31
Un-dried brown rice	18-25	50	0.97	0.34	50	0.96	0.47

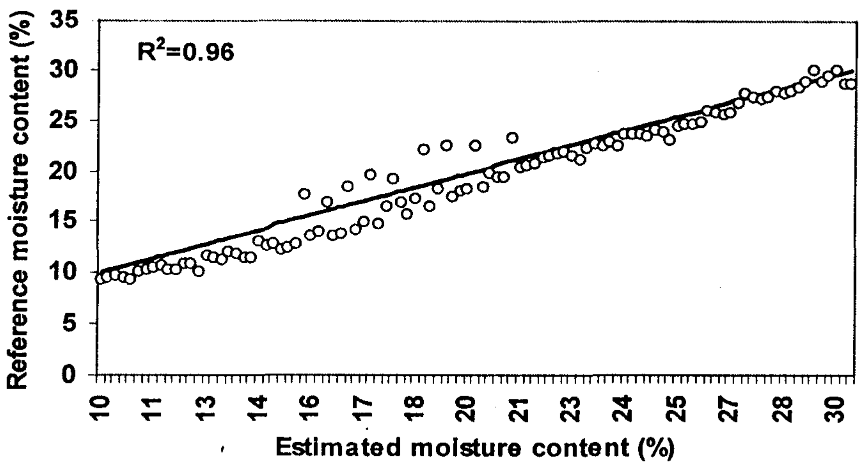

Fig. 2. Relation between reference and estimated moisture content of rough rice using a calibration model obtained from un-dried rough rice spectra with a light path length of 25 mm for Sakha 101 variety

Table 2. Calibration and validation statistics for Sakha 101 brown and milled rice protein contents

	Brown rice							
	Calibration model				Validation model			
	n	%	R^2	SEP	n	%	R^2	SEP
Un-dried rough rice	50	7.7	0.82	0.31	50	7.5	0.81	0.29
Dried rough rice	50	7.6	0.84	0.29	50	7.4	0.81	0.29
Un-dried brown rice	50	7.3	0.80	0.36	50	7.4	0.79	0.33
	Milled rice							
	Calibration model				Validation model			
	n	%	R^2	SEP	n	%	R^2	SEP
Un-dried rough rice	50	6.9	0.87	0.29	50	6.9	0.78	0.31
Dried rough rice	50	7.1	0.89	0.28	50	7.1	0.78	0.32
Un-dried brown rice	50	6.9	0.83	0.29	50	7.2	0.77	0.28

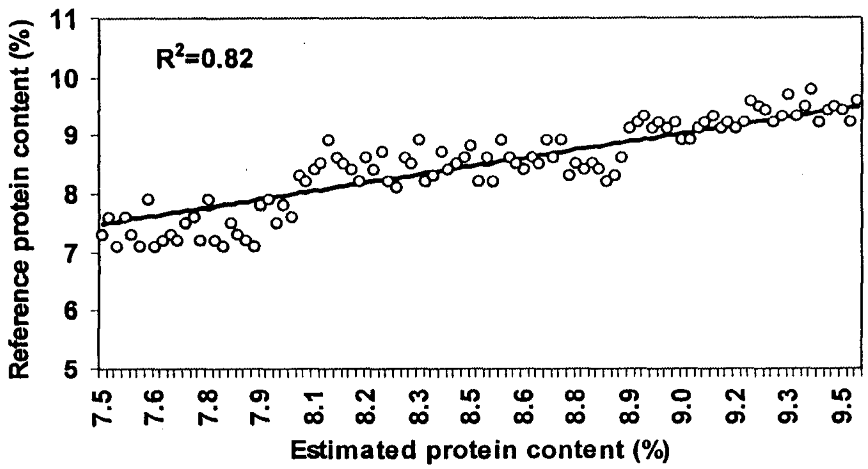

Fig. 3. Relation between reference and estimated protein content of brown rice using a calibration model obtained from un-dried rough rice spectra with a light path length of 25 mm for Sakha 101 variety

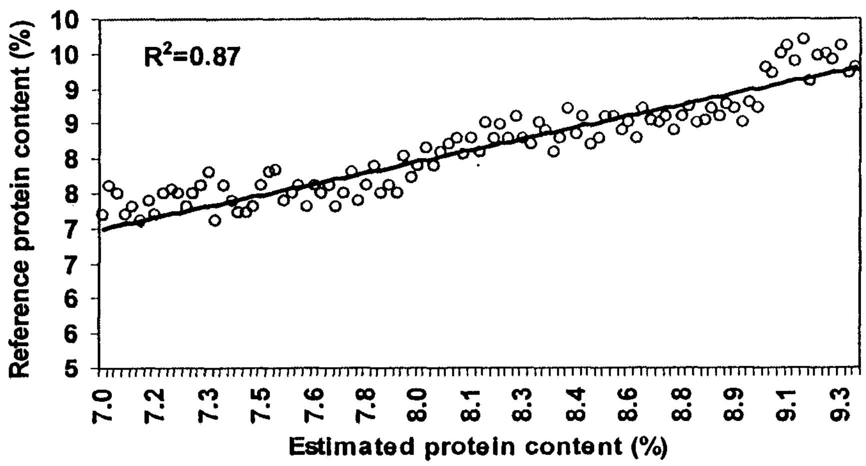

Fig. 4. Relation between reference and estimated protein content of milled rice using a calibration model obtained from un-dried rough rice spectra with a light path length of 25 mm for Sakha 101 variety

Table 3. Calibration and validation statistics for Sakha 101 milled rice amylose contents

	Milled rice							
	Calibration model				Validation model			
	n	%	R^2	SEP	n	%	R^2	SEP
Un-dried rough rice	50	20.6	0.15	0.21	50	20.7	0.04	0.25
Dried rough rice	50	20.5	0.21	0.23	50	20.6	0.01	0.22
Un-dried brown rice	50	20.6	0.13	0.26	50	20.7	0.07	0.25

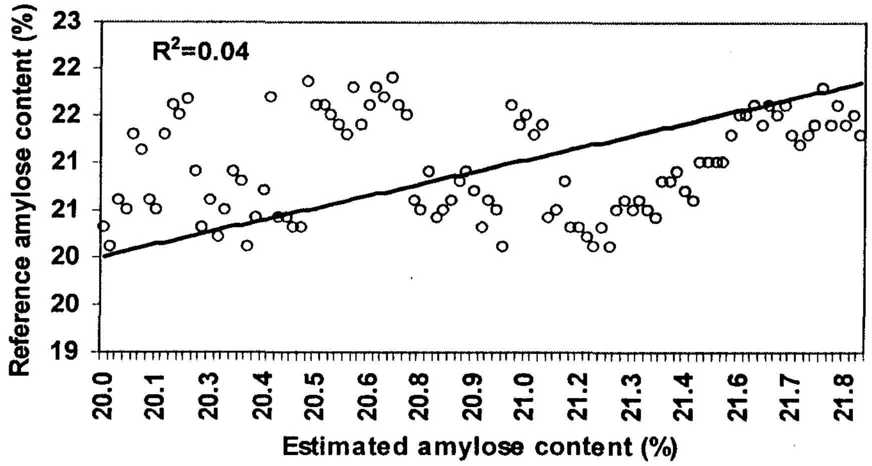

Fig. 5. Relation between reference and estimated amylose content of milled rice using a calibration model obtained from un-dried rough rice spectra with a light path length of 25 mm for Sakha 101 variety

Calibration and validation for rice taste evaluation

Performances of the MLR models and PLS models were almost the same. Calibration models obtained from milled rice appeared to be better than those obtained from brown rice. Calibration models obtained from whole grain milled rice appeared to be better than those obtained from ground milled rice because the sample in the sensory test was neither brown rice nor ground milled rice, and whole grain milled rice was the sample closest in style to cooked rice in the sensory test. The selected wavelength of the MLR models were in the NIR and visible regions. **Fig. (6)** shows a correlation between reference taste value and VIS/NIR validation value. The calibration model used was the best performance one in this study, which was obtained from original spectra of whole grain milled rice using MLR. The correlation coefficient (R^2) of the validation set was 0.83 and the standard error of prediction (SEP) was 0.31.

Correlation between physicochemical properties and sensory evaluation

Correlation coefficients between physicochemical properties and sensory evaluation are shown in **Table (4)**. Amylose content had a significant correlation with hardness (R^2 = 0.41) and cohesiveness (R^2 = –0.42). Protein content had a significant correlation with aroma (R^2 = –0.48), cohesiveness (R^2 = –0.29), and overall flavor (R^2 = –0.47). Free fat acidity had a significant correlation with appearance (R^2= –0.49) and overall flavor (R^2= –0.48). This result indicated that these constituents significantly affected sensory evaluations. Whiteness, saturation, and translucency were rice properties measured with visible light. Whiteness had a significant correlation with overall flavor (R^2= 0.32). Saturation and translucency had significant correlations with appearance (R^2= –0.38 and R^2= 0.58), aroma (R^2= –0.39 and R^2= 0.32), and overall flavor (R^2= –0.37 and R^2= 0.39). This result suggested that the rice properties measured with visible light gave important information about rice taste. Texturogram had a significant correlation with hardness (R^2= 0.48) and cohesiveness (R^2= –0.29). However, correlations between amylogram and rapid visco analyzer measurements of the viscosity of rice flour paste, and panelist's evaluations of the texture of cooked rice were very low. Overall flavor had a highly significant correlation with the appearance (R^2= 0.78), aroma (R^2= 0.71), and cohesiveness (R^2= 0.68) of cooked rice. Cooked rice with a good appearance, nice aroma, and high cohesiveness appeared to get a high taste score. A multiple correlation analysis was made to find out the contribution of appearance, aroma and cohesiveness to overall flavor. The coefficient of correlation (R^2) was determined to be 0.75, which meant that about 75% of overall flavor was determined by appearance, aroma, and cohesiveness.

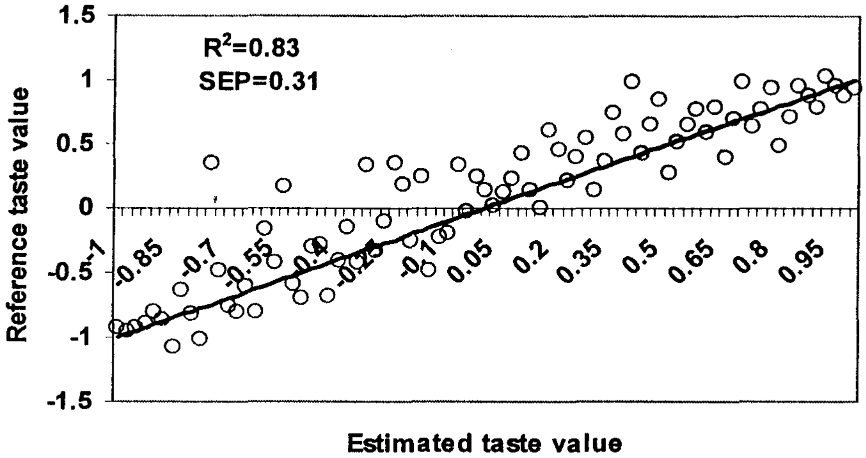

Fig. 6. Relation between reference taste value and VIS/ NIR validation value

Table 4. Correlation coefficient between physicochemical properties and sensory evaluation (n=100)

	Appearance	Aroma	Hardness	Cohesiveness	Overall flavor
Moisture content	0.14	0.15	-0.17	0.13	0.22
Amylose content	0.02	0.11	0.41	-0.42	0.00
Protein content	-0.25	-0.48	0.16	-0.29	-0.47
Free fat acidity	-0.49	-0.26	0.13	-0.11	-0.48
Whiteness	0.23	0.22	0.04	0.17	0.32
Saturation	-0.38	-0.39	0.03	-0.36	-0.37
Translucency	0.58	0.32	0.02	0.06	0.39
Texturogram	-0.13	0.11	0.48	-0.29	-0.25
Amylogram	-0.06	-0.13	-0.17	-0.11	0.04
Appearance	1.00	0.57	-0.29	0.45	0.78
Aroma		1.00	-0.12	0.36	0.71
Hardness			1.00	-0.49	-0.38
Cohesiveness				1.00	0.68
Overall flavor					1.00

Table (5) shows measured and calculated rice taste values. The procedure of statistics software SAS was used to fit the data and the following model was obtained. The model can be used to calculate the rice taste value according to rice ingredient content (correlation coefficient was 0.94).

$$\mathbf{RTV = 34136 / \{(Am)^{1.38} * (Pr)^{0.79} * (16+|16-M|)^{0.07} * (Fa)^{0.25}\} - 1.56}$$

Where

RTV = Rice taste value
Am = Rice amylose content
Pr = Rice protein content
M = Rice moisture content
Fa = Rice fat acid content

CONCLUSIONS

- Some physicochemical properties, such as protein content, free fat acidity, saturation, and translucency significantly affected overall flavor. The better the appearance and aroma, and the higher the cohesiveness of cooked rice was, the higher the taste evaluation.

Table 5. The contents and taste value (obtained from the above model) of Sakha 101 rice variety

Amylose content %	Protein content %	Moisture content %	Fat acid content %	Rice taste measured value	Rice taste calculating value
17.5	7.2	14.6	6.8	73	69
17.3	7.5	14.5	6.8	71	67
18.6	7.9	14.3	6.8	62	58
17.5	7.6	14.3	6.7	74	66
18.3	7.8	14.2	6.5	68	61
18.9	7.8	13.9	6.5	62	58
18.6	7.7	13.8	6.5	63	60
18.9	7.7	13.9	6.5	64	59
17.6	7.8	14.1	6.8	68	64
19.1	8.1	13.6	6.8	60	55
19.3	8.1	13.7	6.8	59	54
18.7	7.9	13.9	6.9	61	57
19.6	7.9	13.8	6.9	57	54
18.5	7.9	14.1	6.9	65	58
16.9	7.6	14.2	6.8	70	69
17.7	7.3	14.6	6.9	73	66
18.9	7.5	13.9	6.6	61	60
18.6	7.5	14.5	6.7	63	61
19.1	7.3	14.1	6.7	63	60
18.7	7.4	14.2	6.7	62	61
18.9	7.5	14.3	6.9	66	59
18.3	7.9	14.6	6.9	66	59
19.7	7.2	14.3	6.7	65	58
18.5	8.1	14.2	6.8	60	57
19.1	7.3	14.3	6.8	65	60
19.5	7.5	14.3	6.9	58	57
19.3	7.5	14.5	6.5	61	58
18.5	7.9	14.2	6.8	60	59
18.7	7.2	14.3	6.7	62	63
18.7	7.6	14.6	6.8	62	60
18.9	7.5	14.3	6.7	64	60

- Calibration models which obtained from whole grain milled rice had higher performance than the others. The information about constituents and appearance was very important in evaluating rice taste using VIS/NIR technology. VIS/NIR technology could be used for classifying rice samples into qualitative groups, such as poor taste, better taste and the best taste.
- NIRT spectroscopy could be used to the determine moisture content and protein content of un-dried whole grain rough rice samples. Although slightly less accurate than NIR models based on dried ground milled rice, the NIRT un-dried whole grain rough rice calibration model for estimating the protein content of brown rice and milled rice was sufficiently accurate for grading un-dried rough rice when it is transported to a drying facility from rice fields. However, taste of rice and its acceptability need to be considered to adopt lower milling degree.

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حوليات العلوم الزراعية
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الكشف عن جودة محصول الأرز والتى تتأثر بعملية التقشير وذلك باستخدام التحليل الطيفى للأشعة تحت الحمراء

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يتم فى مصر تقييم جودة الأرز عن طريق نسبتى التبييض والكسر فى الحبة حتى الأن. ولكن فى هذة التجربة تم استخدام خاصية التحليل الطيفى لانعكاس الأشعة تحت الحمراء فى تقييم جودة محصول الأرز عن طريق الطعم والنكهة (المذاق). وقد تم فى بداية التجربة عمل تقييم مبدئى بواسطة استخدام معادلة الانحدار المتعدد كدلالة لعملية الجودة قبل تنفيذ التجربة الفعلية. وقد أوضحت النتائج المبدئية أن معامل الارتباط لصنف سخا ١٠١ وصل الى ٨٣% عند خطأ معيارى قدرة ٣١% أثناء تقييم قيمة الجودة لحبوب الأرز عن طريق الطعم والنكهة.

وقد تم بعد ذلك استخدام خاصية التحليل الطيفى لانعكاس الأشعة تحت الحمراء فى تقييم جودة محصول الأرز (عن طريق الطعم والنكهة). وذلك أولا بتحليل حبوب الأرز لمعرفة بعض خصائصها الطبيعية والكيميائية مثل المحتوى الرطوبى للحبوب ونسبة البروتين والأميلوز داخل الحبة والتى تعد من أهم عوامل تقييم جودة الأرز حسب التقييم العالمى المستخدم فى ذلك. وثانيا باستخدام الأشعة تحت الحمراء ثم مقارنة النتائج المتحصل عليها فى كلتا الحالتين. وقد تم فى سبيل الحصول على ذلك استخدام أنواع الأرز الشعير (Rough rice) والأرز المبيض (Milled rice) وكذلك الأرز الغير مبيض (Brown rice).

وقد أوضحت النتائج أن معامل الارتباط وصل الى ٩٦% عند خطأ معيارى قدرة ٤٦% للمحتوى الرطوبى للأرز الشعير. وأن معامل الارتباط وصل الى ٨٢% عند خطأ معيارى قدرة ٣١% لنسبة البروتين للأرز الغير مبيض (Brown rice) وكان معامل الارتباط ٨٧% عند خطأ معيارى قدرة ٢٩% لنسبة البروتين للأرز المبيض (Milled rice). أما معامل الارتباط لنسبة الأميلوز للأرز المبيض (Milled rice) والخطأ المعيارى لهذة النسبة كانتا ٤٠% و٢٥% على الترتيب.

وعلى ذلك فانه قد تم تصنيف الأرز (باستخدام خاصية التحليل الطيفى لانعكاس الأشعة تحت الحمراء) الى مجموعات حسب نسبتى البروتين والأميلوز داخل الحبة الى مجموعة عالية البروتين وأخرى منخفضة البروتين وكذلك بالنسبة للأميلوز. وبالتالى فانه يمكن تصنيف الأرز حسب المذاق الى أرز ذو نكهة أفضل من الأخر (بمعنى أرز عالى الجودة وأخر أقل جودة). لذا فان تقييم جودة محصول الأرز حسب نسبة البروتين والأميلوز داخل الحبة تعتبر من أفضل الطرق فى التقييم للحصول على منتج عالى الجودة يمكن تصديرة حسب التصنيف العالمى للجودة.

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