Original Article

Texture of Cooked Selected KDML 105 Rice Mutants and Its Related Variables

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Abstract

The relation of cooked rice texture, pasting properties, contents of amylose, protein, and fat of selected KDML 105 rice mutants, obtained from low energy ion beam bombardment including HyKOS3, HyKOS3-1, HyKOS7-1, HyKOS16, HyKOS21 and HyKOS22, together with KDML 105 and Hom Viengping was studied. The multiple regression analysis showed that hardness was related to amylose content, water addition when cooked, setback and peak time. Cohesiveness was related to amylose and protein content as well as setback. Adhesiveness was related to protein content and water addition when cooked. Springiness and chewiness were related to amylose and protein content, setback and peak time. For pasting properties, it was found that breakdown, setback and peak time was related to amylose and protein content. Pasting temperature was related to amylose, protein, and fat content, while final viscosity was related to amylose content only.

Keywords: KDML 105rice mutants, texture, pasting properties, amylose, protein

Introduction

Rice is a major food crop for the people of the world in general and Asians in particular: Nearly 90% of the world's rice is produced and consumed in this region[1]. KDML 105, Thai Hom Mali rice, or Thai jasmine rice, is popular worldwide among rice consumers because of its distinctive properties. It is classified as non-glutinous rice with long grain and slender shape. Its grain is transparent or clear and contains very few chalky kernels. When cooked, it has a soft texture and presents a natural fragrant smell. Unfortunately, it is susceptible to all major diseases and insect pests[2]. And it can be cultivated only once a year in the in-season period (July–December)[3] and only in rainfed area, the North and Northeast of Thailand[2].

Many efforts have been used to increase the production of rice with desired properties of KDML 105. One of them is the application of low energy ion beam bombardment to produce new genetic modifications. Its application in KDML 105 at Chiang Mai University has resulted in many new lines with characters that allow higher yields including semi-dwarfism and photoperiod insensitivity[3], blast disease resistance[4], and drought resistance[5], and characters that provide potential health benefit including dark purple/black pericrap[3,5-6] and more antioxidant enzyme activity[7].

Since the soft texture of cooked KDML 105 is desirable, texture parameters, pasting properties and chemical contents of 6 KDML 105 rice mutants cultivated in the in-season and off-season periods, KDML 105 (control for the in-season period) and Hom Viengping (control for the off-season period) were studied to find out variables related to texture of cooked rice. Six KDML 105 rice mutants were selected in this work because they could yield as much as 910 – 1,725 kg/rai, when cultivated with good care[8].

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Materials and Methods

1. Rice Sample

All rice samples including KDML105, Hom Viengping and two crops of 6 selected KDML 105 rice mutants (HyKOS3, HyKOS3-1, HyKOS7-1, HyKOS16, HyKOS21 and HyKOS22) were supplied by the Science and Technology Research Institute, Chiang Mai University.

2. Cooking Method

The 150 g of rice sample was washed, drained and weighted. Water was added to make a certain rice and water ratio at 1:1.50, 1:1.75 and 1:2.0 (w/w). Cooking was done by the electric rice cooker (SHARP Model KSH 206, Thai City Electric, Bangkok, Thailand) at 300 watts for 10 – 21 min depending on rice and water ratio and rice samples.

3. Texture Measurement

Cooked rice was kept in the inner pot of the electric rice cooker (3 hr) for cooling down to room temperature. Its texture parameters were measured by Lloyd Universal testing Machine (Model LR10K, Lloyd Instruments, Hampshire PO15 5TT, UK). Cooked rice was compressed by a 10-mm diameter steel cylinder probe with a flat end. Test speed was 100 mm/min and the sample was compressed to 75%, held for 3 sec., released and compressed again to complete the two-cycle compression test[9]. The measurement was repeated ten times per sample.

Texture parameters including hardness (maximum force, kgf), cohesiveness (ratio of positive force area of the second compression to that of the first compression) and adhesiveness (negative area between the first and second compressions, kgf.mm), springiness (height that sample springs back after the first compression, mm) and chewiness (energy required to chew a solid food to the point required for swallowing it = hardness x cohesiveness x springiness, kgf.mm) were derived from the instrument software.

4. Pasting Properties Measurement

Rice sample was ground to make rice flour. Its pasting properties were measured by Rapid Visco Analyzer (Model 3-D RVA, Newport Scientific, Sydney, Australia). Three gram of rice flour and 25 ml of distilled water were mixed. The sample was held at 50 °C for 1 min, heated to 95 °C at a rate of 12 °C/min, held at 95 °C for 2.5 min, cooled to 50 °C at a rate of 12 °C/min and held at 50 °C for 2.5 min. The rotating speed of the paddle was kept at 160 rpm throughout the run except at the first 10 s the paddle speed was 960 rpm[10]. All measurements were triple replicated.

The pasting properties including peak viscosity (maximum viscosity when heated, cP), peak time (time at peak viscosity, min), trough viscosity (minimum viscosity when heated, cP), breakdown (heat resistance and stickiness = peak viscosity – trough viscosity, cP), final viscosity (final viscosity after cooling down, cP), setback (gel formation and hardness = final viscosity – peak viscosity, cP), and pasting temperature (°C)[11] were derived from the instrument software.

5. Chemical Analysis

Amylose content was analyzed by Spectrophotometer[12]. Protein and fat contents were analyzed by AOAC official method[13].

6. Statistical Analysis

Each data set was analyzed by analysis of variance (Completely Randomized Design, CRD) and their means were compared by Tukey (a)'s w test. Multiple regression analysis was applied between texture parameters and chemical contents together with rice and water ratio, between texture parameters and pasting properties, and between pasting properties and chemical contents. All analysis was done by SPSS 16.0 and all graphs were created by Gnuplot 4.6.

Results and Discussions

1. Texture and Pasting Properties Measurement and Chemical Analysis

Results of texture parameters are shown in (Table 1), They were average values using 3 rice and water ratios (1:1.5, 1:1.75 and 1:2.0) When cooked. It was found that HyKOS3-1 and HyKOS22 were the hardest varieties with more cohesive, more springy and more chewy texture. Hom Viengping was harder than KDML 105 but their other parameters were similar. Other rice varieties had similar texture to Hom Viengping or

KDML 105, but HyKOS3 and HyKOS7-1 were less springy.

Pasting properties of samples were different than their texture parameters as shown in (Table 2) because pasting properties were analyzed with a certain water quantity, while texture parameters were analyzed by varying water quantity because the increase of rice and water ratio when cooked could make HyKOS3-1 and HyKOS22 softer[9].

Chemical analysis in (Table 3) showed that HyKOS3-1 and HyKOS22, the hardest varieties, contained higher amylose content at 20.63 ± 1.32 and 23.45 ± 1.08%, respectively, which could be classified into intermediate amylose type (containing 20 – 25% amylose), while other rice varieties were low amylose type (10 – 20%). The appropriate quantity of cooking water depends on the level of amylose. Rice with low amylose needs less water and too much water addition make rice soggy and pasty. Rice with high amylose will be hard if water addition is not enough. The recommended rice and water ratio for KDML 105 is 1:1.7 by weight, and it should be reduced when a large amount of rice is cooked[2].

Table 1 Texture parameters of cooked Hom Viengping, KDML105 and its 6 selected mutants.

Rice varieties	Hardness (kgf)	Cohesiveness	Adhesiveness (kgf.mm)	Springiness (mm)	Chewiness (kgf.mm)
Hom Viengping	$0.89^{b} \pm 0.21$	$0.18^{b} \pm 0.03$	$0.25^{bc} \pm 0.18$	$8.81^{b} \pm 1.76$	$1.43^{b} \pm 0.57$
KDML105	$0.57^{c} \pm 0.12$	$0.19^{b} \pm 0.05$	$0.17^{c} \pm 0.12$	$8.33^{b} \pm 3.15$	$0.95^{b} \pm 0.50$
HyKOS3	$0.74^{bc} \pm 0.22$	$0.17^{b} \pm 0.03$	$0.33^{b} \pm 0.03$	$6.59^{c} \pm 1.26$	$0.88^{b} \pm 0.43$
HyKOS3-1	$1.30^{a} \pm 0.39$	$0.23^{a} \pm 0.05$	$0.67^{a} \pm 0.27$	$13.05^{a} \pm 1.83$	$4.10^{a} \pm 2.14$
HyKOS7-1	$0.73^{bc} \pm 0.15$	$0.18^{b} \pm 0.04$	$0.40^{b} \pm 0.25$	$6.21^{c} \pm 1.38$	$0.90^{b} \pm 0.52$
HyKOS16	$0.72^{bc} \pm 0.19$	$0.18^{b} \pm 0.04$	$0.37^{b} \pm 0.33$	$6.95^{bc} \pm 2.17$	$0.98^{b} \pm 0.50$
HyKOS21	$0.60^{bc} \pm 0.13$	$0.17^{b} \pm 0.03$	$0.29^{bc} \pm 0.18$	$7.79^{b} \pm 1.65$	$0.81^{b} \pm 0.31$
HyKOS22	$1.77^{a} \pm 0.64$	$0.24^{a} \pm 0.05$	$0.32^{b} \pm 0.17$	$12.73^{a} \pm 2.13$	$5.58^{a} \pm 2.75$

[a, b, ..] Means with different letters in the same column were significantly different ($p \leq 0.05$).

Table 2 Pasting properties of Hom Viengping, KDML105 and its 6 selected mutants.

Rice varieties	Peak viscosity (cP)	Peak time (min)	Trough viscosity (cP)	Breakdown (cP)
Hom Viengping	$2245^{b} \pm 139$	$5.9^{ab} \pm 0.1$	$1310^{b} \pm 82$	$936^{b} \pm 62$
KDML105	$1459^{d} \pm 151$	$5.9^{ab} \pm 0.1$	$901^{d} \pm 89$	$558^{d} \pm 73$
HyKOS3	$770^{e} \pm 162$	$5.6^{b} \pm 0.2$	$430^{e} \pm 93$	$340^{e} \pm 70$
HyKOS3-1	$2552^{a} \pm 124$	$6.2^{a} \pm 0.3$	$2131^{a} \pm 87$	$421^{e} \pm 48$
HyKOS7-1	$2280^{b} \pm 128$	$5.8^{ab} \pm 0.4$	$1269^{b} \pm 75$	$1011^{ab} \pm 94$
HyKOS16	$2528^{a} \pm 117$	$5.7^{b} \pm 0.2$	$1329^{b} \pm 73$	$1199^{a} \pm 82$
HyKOS21	$1925^{c} \pm 114$	$5.9^{ab} \pm 0.3$	$1112^{c} \pm 90$	$813^{c} \pm 38$
HyKOS22	$1372^{d} \pm 294$	$5.3^{b} \pm 0.4$	$891^{d} \pm 211$	$481^{de} \pm 109$

[a, b, ..] Means with different letters in the same column were significantly different ($p \leq 0.05$).

Table 2 (continued) Pasting properties of Hom Viengping, KDML105 and its 6 selected mutants.

Rice varieties	Final viscosity (cP)	Setback (cP)	Pasting Temperature (°C)
Hom Viengping	2525 ^{b} $\pm$ 88	280 ^{c} $\pm$ 82	86.7 ^{a} $\pm$ 0.4
KDML105	1605 ^{d} $\pm$ 117	146 ^{d} $\pm$ 62	87.5 ^{a} $\pm$ 1.2
HyKOS3	956 ^{e} $\pm$ 161	187 ^{d} $\pm$ 40	87.8 ^{a} $\pm$ 2.2
HyKOS3-1	4070 ^{a} $\pm$ 113	1518 ^{a} $\pm$ 82	83.2 ^{b} $\pm$ 1.0
HyKOS7-1	2294^{bc} $\pm$ 165	14 ^{e} $\pm$ 197	76.8 ^{c} $\pm$ 1.7
HyKOS16	2190 ^{c} $\pm$ 24	-338 ^{f} $\pm$ 127	73.3 ^{d} $\pm$ 1.0
HyKOS21	1839 ^{d} $\pm$ 106	-86 ^{e} $\pm$ 32	83.7 ^{b} $\pm$ 2.3
HyKOS22	1876 ^{d} $\pm$ 366	504^{b} $\pm$ 127	78.3 ^{c} $\pm$ 0.9

$^{a, b, ..}$ Means with different letters in the same column were significantly different ($p \leq 0.05$).

Table 3 Chemical analysis of Hom Viengping, KDML105 and its 6 selected mutants.

Rice varieties	Amylose (%)	Protein (%)	Fat (%)
Hom Viengping	15.99^{c} $\pm$ 0.61	8.87^{a} $\pm$ 0.19	0.79^{a} $\pm$ 0.04
KDML105	12.87^{e} $\pm$ 0.95	4.19^{c} $\pm$ 0.40	0.30^{b} $\pm$ 0.12
HyKOS3	13.93^{de} $\pm$ 1.27	9.17^{a} $\pm$ 0.16	0.58^{ab} $\pm$ 0.05
HyKOS3-1	20.63^{b} $\pm$ 1.32	8.08^{b} $\pm$ 0.33	0.51^{ab} $\pm$ 0.13
HyKOS7-1	13.63^{de} $\pm$ 0.88	8.32^{ab} $\pm$ 0.98	0.82^{a} $\pm$ 0.20
HyKOS16	14.46^{d} $\pm$ 0.57	8.37^{ab} $\pm$ 0.32	0.65^{a} $\pm$ 0.16
HyKOS21	13.58^{de} $\pm$ 0.84	9.45^{a} $\pm$ 0.76	0.57^{ab} $\pm$ 0.25
HyKOS22	23.45^{a} $\pm$ 1.08	8.30^{ab} $\pm$ 0.71	0.39^{b} $\pm$ 0.17

$^{a, b, ..}$ Means with different letters in the same column were significantly different ($p \leq 0.05$).

Data were reported on the basis of 14% grain moisture content.

2. Multiple Regression Analysis

Multiple regression analysis between texture parameters and chemical contents or pasting properties showed that hardness was related to amylose content, water addition when cooked, setback and peak time. Cohesiveness was related to amylose and protein content as well as setback. Adhesiveness was related to protein content and water addition when cooked. Springiness and chewiness were related to amylose and protein content, set back and peak time (Figure 1-2). These results agreed with Rice Department[2] which mentioned that rice with high amylose will be harder and more water must be put to make it soften and Supakitkanjana[11] who mentioned that setback is a parameter representing gel formation and hardness.

For pasting properties, it was found that breakdown, setback and peak time was related to amylose and protein content. Pasting temperature was related to amylose, protein, and fat content, while final viscosity was related to amylose content only (Figure 3). These results agreed to a work of Fitzgerald et al.[14] who found that protein and fat also affect to pasting properties of rice flour.

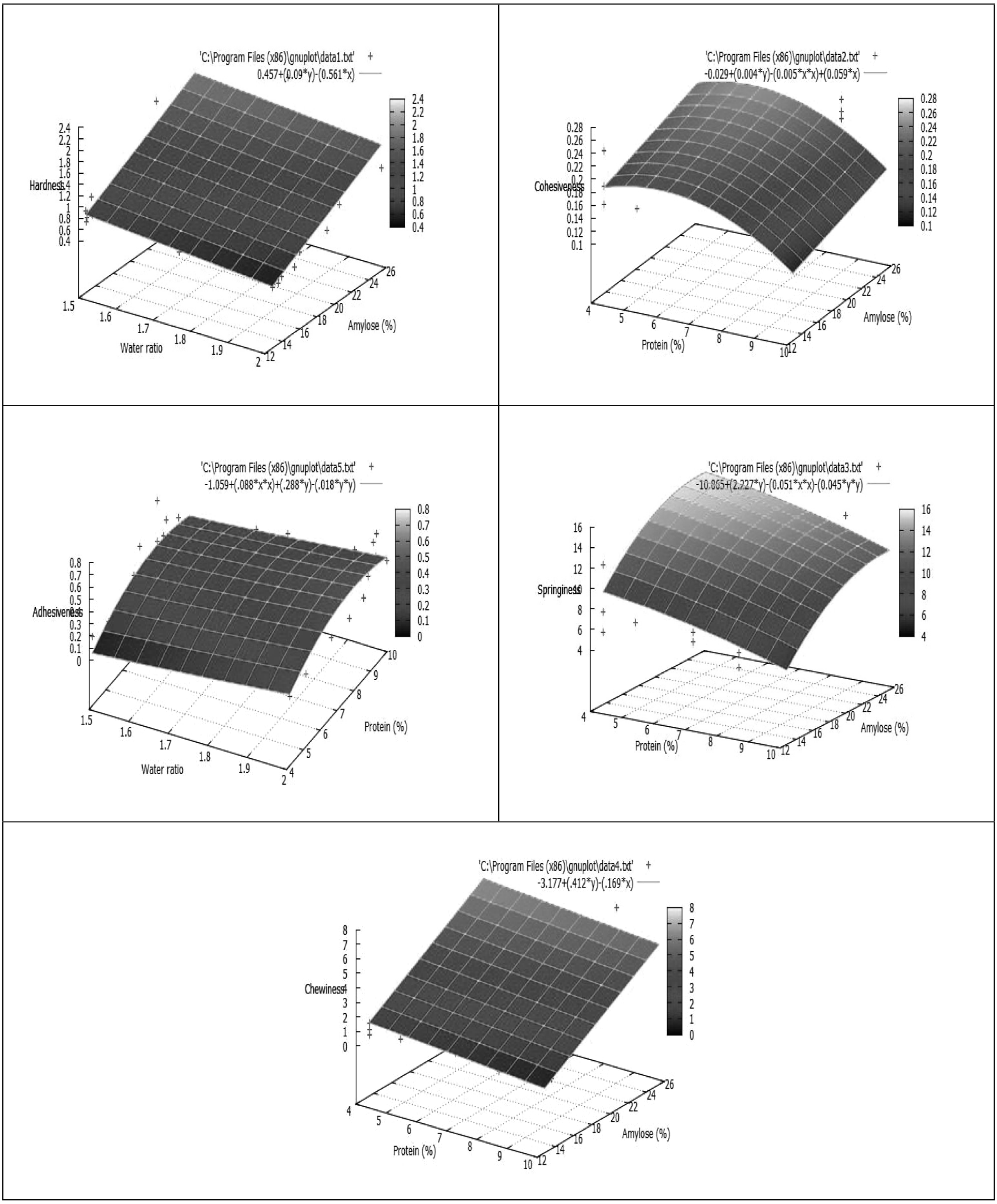

Figure 1 Multiple regression analysis between texture parameters and chemical contents, or rice and water ratio.

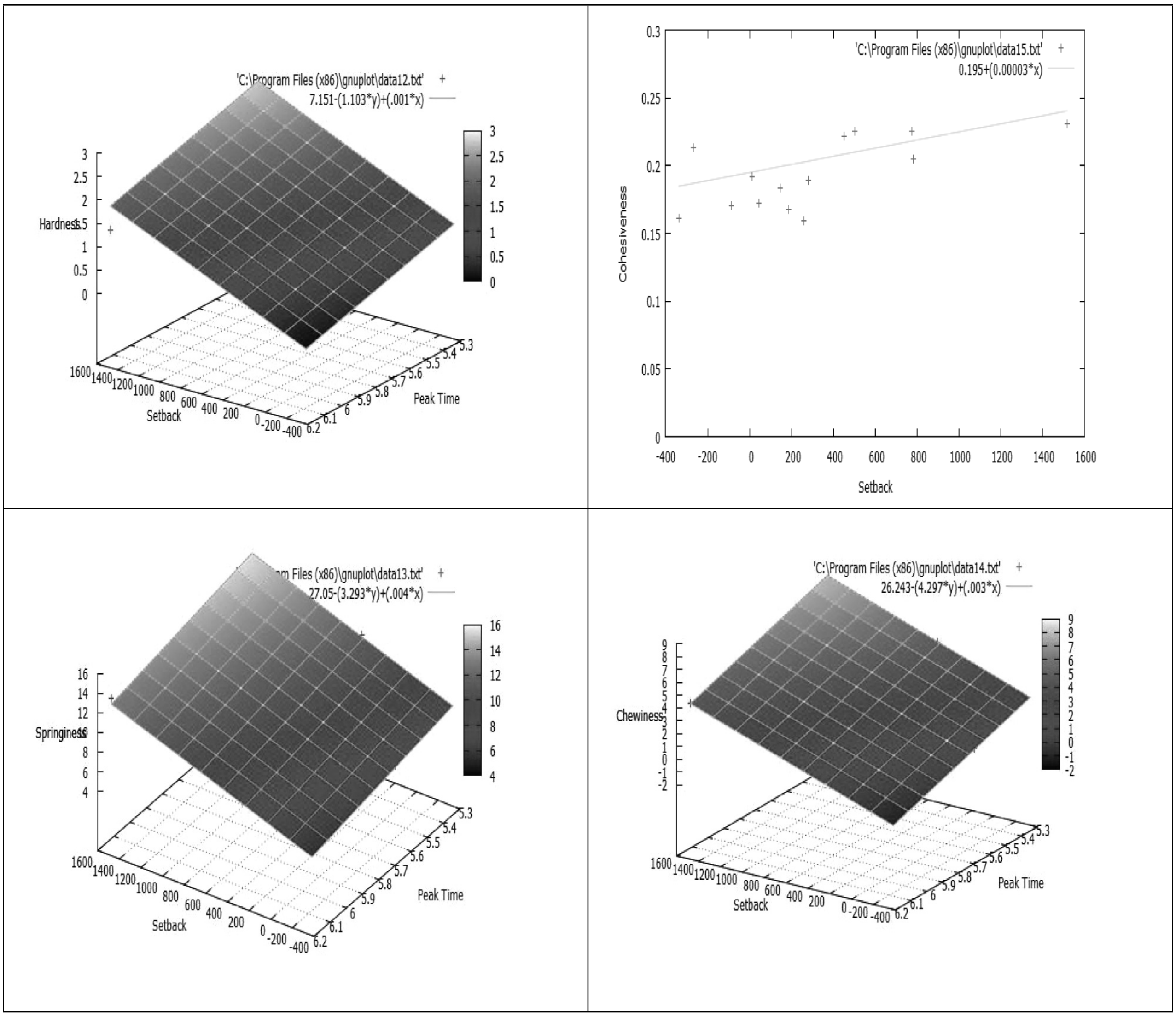

Figure 2 Multiple regression analysis between texture parameters and pasting properties.

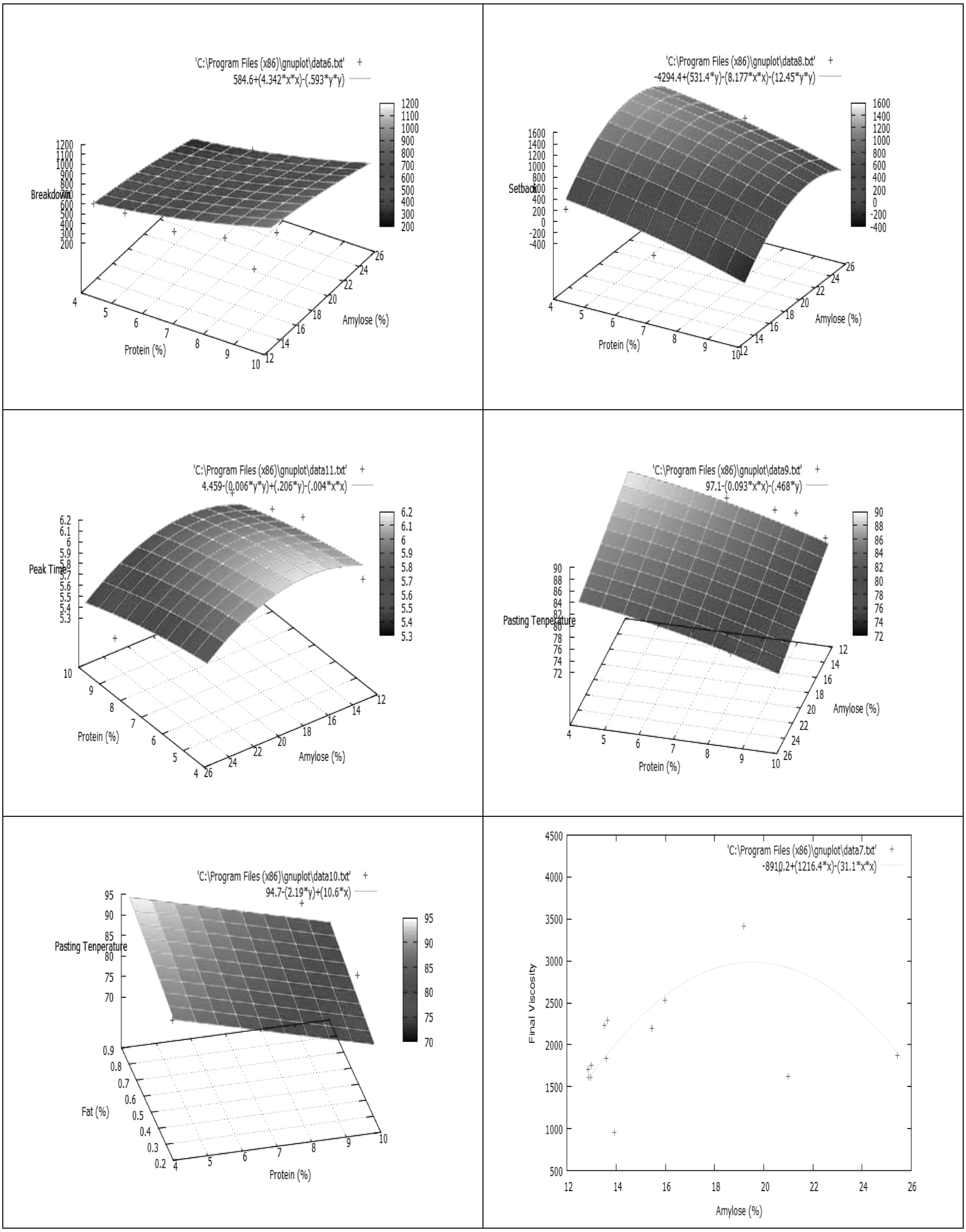

Figure 3 Multiple regression analysis between pasting properties and chemical contents.

Conclusion

Texture parameters of cooked selected KDML 105 rice mutants were related to amylose and protein contents, as well as rice and water ratio. Amylose, protein and fat contents were also related to pasting properties. Setback could be a pasting parameter representing hardness, cohesiveness, springiness and chewiness. This work also showed that peak time could be another variable reflecting texture parameters of cooked rice. Since both texture and pasting parameters have been used for identifying the properties of rice, the correlation between texture and pasting parameters in this work could be useful when the prediction of texture parameters from pasting parameters or vice versa is needed.

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