4.3 Experiment III: Quality of ‘KDML 105’ and ‘Suphan Buri 1’ as affected by high temperature treatment

4.3.1 Quality of ‘KDML 105’

4.3.1.1 Moisture content of paddy (%)

The moisture content (MC %) of the paddy is shown in Table 4.3.1 The initial moisture level was 10.3% and the final moisture content after storage in an incubator at 45°C for one month significantly decreased to 9.6%.

4.3.1.2 Colour of paddy (value)

The L*, a*, and b* values describing the colour of paddy is shown in Table 4.3.1 The L* (lightness) of paddy decreased after one month of storage, but it was not significantly different. The a* value (green to red) significantly increased after storage for one month. The b* value describing the yellowness significantly increased, but the hue angle significantly decreased after storage for 1 month.

4.3.1.3 Colour of brown rice (value)

The colour of brown rice is depicted in Table 4.3.2 The L* value was slightly decreased after storage for 1 month.

The a* and b*value significantly increased after storage. However, the hue angle slightly decreased and was similar to the L* value after storage.

4.3.1.4 Determination to detect brown rice grains

1**)** Head rice of brown grains (%)

The head rice of brown rice significantly increased after storage for 1 month.

2**)** Imperfect grains of brown rice grains **(**%**)**

A. Chalky of grains (%)

The chalkiness of grains of brown rice significantly decreased after storage for 1 month.

B. Immature grains (%)

The immature grains of brown rice significantly increased after storage for 1 month.

C. Cracked grains (%)

The cracked grains of brown rice significantly decreased after storage for 1 month.

D. Defect grains (%)

The defect grains of brown rice significantly increased after storage for 1 month.

E. Big broken grains (%)

The big broken grains of brown rice decreased, but were not changed during storage.

F. Small broken grains (%)

The small broken grains of brown rice slightly decreased in storage for 1 month, even though they were not significantly different than the initial sample.

G. Immature paddy (%)

The immature paddy significantly decreased after storage for 1 month.

H. Un–dehulled grains (%)

The un–hulled grains significantly decreased after storage for 1 month.

I. Husks of paddy (%)

The husks of paddy significantly increased after storage for 1 month.

J. The small species of rice (%)

The small species of brown rice significantly increased after the high temperature treatment. The result was indicated from the storage temperature and milling machine.

4.3.1.5 Colour of milled rice (value)

Table 4.3.3 shows the milled rice colour. The L* value of milled rice increased slightly, whereas the increases of a* and b* values were statistically significant. The h°, however, decreased after storage.

4.3.1.6 Determination to detect milled rice grains

1**)** Head rice of milled rice grains (%)

The whole grains of milled rice significantly decreased about 5% after storage for 1 month.

2**)** Imperfect grains of milled rice grains (%)

A. Chalky of grains (%)

The milled rice presented significantly lower percent chalkiness after storage for 1 month.

B. Cracked grains (%)

The cracked milled rice was reduced by storage at 45°C for 1 month.

C. Defect grains (%)

The defect milled rice grains significantly increased after storage for 1 month.

D. Big broken grains (%)

The big broken grains of milled rice decreased, but were not significantly different after storage for 1 month.

E. Small broken grains (%)

Storage for 1 month significantly decreased small broken grains of milled rice.

F. Un–dehulled grains (%)

The un–hulled grains significantly increased after storage for 1 month.

G. Bran (%)

The bran of milled rice significantly decreased after the high temperature treatment.

H. Small species of rice (%)

The small species of rice significantly increased after the high temperature treatment.

4.3.1.7 Kernel dimension of paddy and brown rice (length, width, and thickness)

The length, width and thickness of paddy and brown rice are presented in Table 4.3.1. The length and width increased slightly after storage for 1 month, but the thickness of paddy rice was not changed during the high temperature treatment.

The length, width and thickness of brown rice slightly increased, but it was not significantly different than the initial sample (Table 4.3.1).

The length of milled rice slightly decreased, but the kernel width increased slightly after storage for 1 month (Table 4.3.1). The thickness of milled rice did not change during the high temperature treatment.

Table 4.3.1 Physical characteristics of 'KDML 105' paddy incubated at 45°C for 1 month.

Parameters	Incubation (month)		T-test
	0	1	
1. Moisture content (%)	10.27	9.66	*
2. Colour(value)			
- L*	60.42	59.65	ns
- a*	6.08	7.30	**
- b*	27.90	29.66	*
- h°	77.71	76.18	**
3.Kernel dimension (mm)			
- Length	10.36	10.42	ns
- Width	2.18	2.23	ns
- Thickness	1.84	1.84	ns

The different means in columns separated by small letters indicate statistical significance according to the T-test ($P<0.05$). The absence of letters indicates statistical non-significance: ns = no significance, *statistically significant at $P<0.05$, **statistically significant at $P<0.01$.

Table 4.3.2 Physical characteristics of 'KDML 105' brown rice incubated at 45°C for 1 month.

1. Colour (value)			
- L*	60.13	58.93	ns
- a*	2.89	3.28	*
- b*	17.87	19.65	**
- h°	80.81	80.53	ns
2. Determination to detect grains			
1) Head of whole grains (%)	47.28	53.21	**
2) Imperfect grains (%)			
- Chalky grains	1.04	0.51	*
- Immature grains	1.39	1.37	ns
- Cracked grains	4.35	0.99	**
- Defect grains	2.33	2.39	*
- Big broken grains	1.24	1.09	ns
- Small broken grains	6.37	6.36	ns
- Un-dehulled grains	11.3	1.22	**
- Immature paddy	2.06	0.71	**
- Hulls/husks	21.92	28.15	**
- Small species of rice	0.67	1.88	*
3. Kernel dimension (mm)			
- Length	7.63	7.65	ns
- Width	2.04	2.05	ns
- Thickness	1.68	1.71	ns

The different means in columns separated by small letters indicate statistical significance according to the T-test (*P‹0.05*). The absence of letters indicates statistical non-significance: ns = no significance, *statistically significant at *P*‹0.05, **statistically significant at *P*‹0.01.

Table 4.3.3 Physical characteristics of 'KDML 105' milled rice incubated at 45 °C for 1 month.

Parameters	Incubation (month)		T-test
	0	1	
1. Colour (value)			
- L*	62.31	63.74	ns
- a*	0.01	0.28	*
- b*	8.69	11.35	**
- h°	89.96	88.60	*
2. Determination to detect grains			
1**)** Head rice of whole grains (%)	42.23	37.37	*
2) Imperfect grains (%)			
- Chalky grains	1.04	0.66	**
- Cracked grains	0.48	0.12	**
- Defect grains	0.10	0.60	**
- Big broken grains	3.15	2.56	ns
- Small broken grains	13.71	10.26	**
- Un–dehulled grains	0.42	0.67	**
- Bran	14.04	10.07	**
- Small species of rice	24.80	37.61	**
3.Kernel dimension (mm)			
- Length	7.16	7.15	ns
- Width	1.11	1.13	**
- Thickness	1.72	1.72	ns

The different means in columns separated by small letters indicate statistical significance according to the T-test (*P‹0.05*). The absence of letters indicates statistical non-significance: ns = no significance, *statistically significant at *P*‹0.05, **statistically significant at *P*‹0.01.

4.3.1.8 Amylose content (%)

The amylose content is depicted in Table 4.3.4 The amylose content slightly increased after storage for 1 month.

4.3.1.9 Elongation ratio (mm)

The elongation ratio of cooked rice significantly increased after storage for 1 month (Table 4.3.4).

4.3.1.10 Water absorption (%)

Water absorption increased after storage for 1 month; it was not significantly different than the initial sample.

4.3.1.11 Texture of cooked rice hardness and stickiness (N)

The effect of the high storage temperature at 45°C on the textural characteristics of cooked rice is shown in Table 4.3.4 The cooked rice hardness significantly increased; however, the stickiness was reduced after storage for 1 month.

Table 4.3.4 Chemical and physicochemical characteristics of 'KDML 105' milled rice incubated at 45°C for 1 month.

Parameters	Incubation(month)		T-test
	0	1	
Amylose content (%)	17.5	19.72	ns
Elongation ratio (mm)	1.46	1.56	**
Water absorption (%)	100.66	106.41	ns
Texture of cooked rice (N)			
- Hardness	24.43	34.78	**
- Stickiness	- 2.37	- 1.87	ns

The different means in columns separated by small letters indicate statistical significance according to the 'T-test ($P<0.05$). The absence of letters indicates statistical non significance: ns = no significance, **statistically significant at $P<0.01$

4.3.2 Quality of 'Suphan Buri 1'

4.3.2.1 Moisture content of paddy (%)

The moisture content (MC %) of paddy of 'Suphan Buri 1' is depicted in Table 4.3.5 The initial moisture level of paddy before storage was 9.6% and significantly decreased to 7.4% after storage for 1 month. The MC% reduced faster due to the high temperature treatment.

4.3.2.2 Colour of paddy (values)

The L*, a*, and b* values describing the colour of paddy are shown in Table 4.3.5 The lightness (L*) value of 'Suphan Buri 1'slightly increased after storage for 1 month, even though it was not significantly different than the initial colour.

The a* value of ‘Suphan Buri 1’increased slightly, but was not statistically significant after storage for 1 month.

The b* value was increased after storage for 1 month, even though it was not significantly different after storage for 1 month.

The hue angle of paddy decreased after storage at 45°C for 1 month. The result indicated that the high temperature treatment might affect the paddy during storage in a hot air oven at 45°C for 1 month.

4.3.2.3 Colour of brown rice (values)

The L*, a*, and b* values of brown rice are depicted in Table 4.3.6. The lightness of the L* value of ‘Suphan Buri 1’ brown rice did not change significantly, but the L* value of brown rice increased after storage in a hot air oven at 45°C for one month.

The greenness of the a* value of ‘Suphan Buri 1’ brown rice decreased, even though it did not change significantly after storage for 1 month.

The b*value of brown rice significantly increased in ‘Suphan Buri 1’. In general, the yellowness of brown rice is affected more strongly during high temperature treatment, and the yellowness may continuously change after the treatment.

The hue angle of brown rice did not change after storage for 1 month.

4.3.2.4 Determination to detect brown rice grains

The results of the head rice of whole grains (perfect grains) and imperfect grains of ‘Suphan Buri 1’ brown rice are shown in Table 4.3.6.

1**)** Head rice of brown rice (%)

The head rice of whole grains of brown rice was significantly increased after storage for 1 month. The result indicated that it depends on grain size, storage temperature and the milling process.

2**)** Imperfect grains of brown rice (%)

A. Chalky grains (%)

The chalkiness of grains of brown rice decreased after storage for 1 month, but there was no difference than the initial sample.

B. Immature grains (%)

The immature grains of brown rice decreased after storage for 1 month, although they did not change during storage.

C. Cracked grains (%)

The cracked grains of brown rice significantly increased after storage for 1 month.

D. Defect grains (%)

The defect grains of brown rice increased after storage for 1 month, although they were not significantly different than the initial sample.

E. Big broken grains (%)

The big broken grains of brown rice significantly decreased after storage for 1 month.

F. Small broken grains (%)

The small broken grains of brown rice significantly decreased after storage for 1 month, even though they were not changed during storage.

G. Un–dehulled grains (%)

The un–hulled grains significantly increased after storage for 1 month.

H. Husks/hulls (%)

The husks of paddy significantly increased after storage for 1 month.

I. Small species of rice (%)

The small species of brown rice significantly decreased after storage for 1 month.

4.3.2.5 Colour of milled rice (values)

The results of L*, a*, b* and hue angle of ‘Suphan Buri 1’ milled rice are shown in Table 4.3.7. The L* value of ‘Suphan Buri 1’ milled rice increased slightly due to storage in a hot air oven at 45°C for 1 month, but it was not statistically significant.

In ‘Suphan Buri 1’, the a* and b* values increased. However, only the increase in the b* value was statistically significant after storage for 1 month.

The hue angle of milled rice did not change after storage for 1 month.

4.3.2.6 Determination to detect milled rice grains

The results of the head rice of whole grains and imperfect grains of ‘Suphan Buri 1’ milled rice are depicted in Table 4.3.7.

1**)** Head rice of milled rice grains (%)

The head rice of whole grains significantly decreased after storage for 1 month compared to the initial sample.

2**)**. Imperfect grains of milled rice grains (%)

A. Chalky grains (%)

The chalkiness of milled rice significantly increased after storage for 1 month.

B. Cracked grains (%)

The cracked grains of milled rice increased after storage for 1 month, even though they were not significantly different than the initial sample.

C. Defect grains (%)

The defect grains significantly increased after storage for 1 month.

D. Big broken grains (%)

The big broken grains of milled rice significantly decreased after storage for 1 month. It was shown that the result depends on storage temperature, MC% and drying.

E. Small broken grains (%)

The small broken grains of milled rice significantly decreased after storage for 1 month. The result indicated that they depend on storage time and the milling process.

F. Un–dehulled grains (%)

The un-dehulled grains significantly increased after storage for 1 month.

G. Bran of milled rice (%)

The bran of milled rice increased, even though it was not significantly different than the initial sample.

H. Small species of rice (%)

The small species of milled rice significantly increased after storage for 1 month.

4.3.2.7 Kernel dimension (length, width and thickness) of paddy and brown rice

The resulting lengths, widths and thicknesses of ‘Suphan Buri 1’ paddy are shown in Table 4.3.5 and 4.3.6 The length of ‘Suphan Buri 1’ decreased slightly after storage for 1 month.

The width of ’Suphan Buri 1’ increased after storage for 1 month, but it was not significantly different than the initial sample. However, the thickness of paddy significantly decreased after storage for 1 month.

The length, width and thickness of brown rice are depicted in Table 4.3.5 and 4.3.6.The length of brown rice slightly increased; nevertheless, it did not change during storage. However, the width of brown rice minorly decreased, but it was not changed after storage for 1 month.

The length, width and thickness of milled rice are depicted in Table 4.3.5 and 4.3.6 The length of milled rice slightly decreased, but it was not significantly different. The width of milled rice slightly changed after the high temperature treatment. However, the thickness of milled rice was not changed during storage for 1 month.

Table 4.3.5 Physical characteristics of 'Suphan Buri 1' paddy incubated at 45°C for 1 month.

Parameters	Incubation (month)		T-test
	0	1	
1. Moisture content (%)	8.8	7.41	**
2. Colour (value)			
- L*	58.48	58.51	ns
- a*	5.74	6.15	ns
- b*	27.05	27.43	ns
- h°	78.01	77.37	ns
3. Kernel dimension (mm)			
- Length	9.85	9.72	ns
- Width	2.24	2.26	ns
- Thickness	1.97	1.89	**

The different means in columns separated by small letters indicate statistical significance according to the T-test ($P<0.05$). The absence of letters indicates statistical non-significance: ns = no significance, **statistically significant at $P<0.01$.

Table 4.3.6 Physical characteristics of 'Suphan Buri 1' brown rice incubated at 45°C for 1 month.

Parameters	Incubation (month)		T-test
	0	1	
1. Colour (value)			
- L*	64.39	65.45	ns
- a*	2.68	2.31	ns
- b*	17.26	17.84	*
- h°	81.18	82.63	*
2. Determination to detect grains			
1) Head of whole grains **(%)**	46.71	50.22	**
2) Imperfect grains (**%)**			
- Chalky grains	10.28	6.94	*
- Immature grains	2.41	2.03	ns
- Cracked grains	0.24	0.33	*
- Defect grains	1.98	2.62	ns
- Big broken grains	0.35	0.24	*
- Small broken grains	5.40	4.69	**
- Un-dehulled grains	0.32	0.92	**
- Hulls/husks	22.05	29.14	**
- Small species of rice	10.20	0.70	**
3.Kernel dimension (mm)			
- Length	7.06	7.07	ns
- Width	2.08	2.05	ns
- Thickness	1.74	1.74	ns

The different means in columns separated by small letters indicate statistical significance according to the T-test ($P<0.05$). The absence of letters indicates statistical non-significance: ns = no significance, *statistically significant at $P<0.05$, **statistically significant at $P<0.01$.

Table 4.3.7 Physical characteristics of 'Suphan Buri 1' milled rice incubated at 45°C for 1 month.

Parameters	Incubation (month)		T-test
	0	1	
1. Colour (value)			
- L*	70.85	71.12	ns
- a*	0.26	0.32	ns
- b*	8.97	10.43	**
- h°	88.28	88.28	ns
2. Determination to detect grains			
1) Head rice of whole grains (%)	42.32	35.00	**
2) Imperfect grains (%)			
- Chalky grains	6.39	8.35	**
- Cracked grains	0.13	0.16	ns
- Defect grains	0.17	0.72	**
- Big broken grains	1.91	0.67	**
- Small broken grains	11.32	12.02	**
- Un-hulled grains	0.32	0.58	*
- Bran	7.59	9.34	ns
- Small species of rice	29.74	33.10	**
3. Kernel dimension (mm)			
- Length	6.79	6.68	ns
- Width	2.02	2.10	*
- Thickness	1.73	1.74	ns

The different means in columns separated by small letters indicate statistical significance according to the T-test (*P‹0.05*). The absence of letters indicates statistical non-significance: ns = no significance, *statistically significant at *P*‹0.05, **statistically significant at *P*‹0.01

4.3.2.8 Amylose content (%)

The amylose content of ‘Suphan Buri 1’ is shown in Table 4.3.8. The amylose content of ‘Suphan Buri 1’ significantly increased after storage for 1 month. The texture of ‘Suphan Buri 1’, a high-amylose content variety, was harder than a low-amylose variety.

4.3.2.9 Elongation ratio (mm)

The elongation ratio of ’Suphan Buri 1’ cooked rice is shown in Table 4.3.8. The elongation of ‘Suphan Buri 1’ cooked rice significantly increased after storage for 1 month.

4.3.2.10 Water absorption (%)

Water absorption of ‘Suphan Buri 1’ is depicted in Table 4.3.8. The water absorption of ‘Suphan Buri 1’ increased after storage for 1 month; nevertheless, it did not change compared to the initial sample.

4.3.2.11 Texture of cooked rice hardness and stickiness (N)

The effect of the high storage temperature of 45°C in a hot air oven on the textural characteristics of cooked rice prepared from paddy stored for 1 month is shown in Table 4.3.8. The cooked rice hardness of ‘Suphan Buri 1’ significantly increased after storage for 1 month. However, the stickiness of cooked rice was reduced after storage for 1 month.

Table 4.3.8 Chemical and physicochemical characteristics of ‘Suphan Buri 1’ milled rice stored at 45°C for 1 month.

Parameters	Storage (month)		T-test
	0	1	
Amylose content (%)	28.87	32.1	**
Elongation ratio (mm)	1.38	1.44	**
Water absorption (%)	121.71	143.16	ns
Texture of cooked rice (N)			
- Hardness	36.28	45.66	**
- Stickiness	- 1.85	- 1.49	ns

The different means in columns separated by small letters indicate statistical significance according to the ‘T-test ($P<0.05$). The absence of letters indicates statistical non-significance: ns = no significance, **statistically significant at $P<0.01$.