

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

5.3.1 Moisture content of paddy (%)

Even though the paddy was kept in sealed aluminum foil bags, the MC of these two cultivars was reduced (Table 4.3.1 and 4.3.5). The temperature of 45°C would enhance water transmission through the package faster and the moisture in the kernels would evaporate more (Sharma and Kuanze 1982). The MC of ‘Suphan Buri 1’ was reduced more than that of ‘KDML 105’. This might be due to the higher initial MC of ‘KDML 105’ and its slimmer kernel dimension (Table 4.3.1 and 4.3.5), resulting in a faster evaporation rate.

5.3.2 Colour of paddy (Value)

The Colour of ‘KDML 105’ paddy was light yellow and it changed to a slightly yellow colour compared to the original colour. On the other hand, the temperature did not affect the ‘Suphan Buri 1’, which presented a brown–yellow colour before incubation. The L^* , a^* , b^* and h° values of the ‘Suphan Buri 1’ paddy were slightly changed (Table 4.3.1 and 4.3.5). Lee et al. (2001) demonstrated that the colour of paddy would change after storage and that temperature was one of the major factors inducing the changing rate. Additionally, the change of the paddy colour was cultivar dependent.

5.3.3 Paddy, brown and milled rice dimension (mm)

‘Suphan Buri 1’ paddy is thicker and shorter than ‘KDML 105’ (Table 4.3.1–4.3.3 and 4.3.5–4.3.7). Generally, the size of the grain kernel will not change during storage. It was also found in this research that the kernel dimension of paddy, brown and milled rice for both cultivars was not significantly influenced by incubation at 45°C.

5.3.4 Colour of brown rice (values)

The colour change of brown and milled rice for both cultivars is similar (Table 4.3.2, 4.3.3, 4.3.6 and 4.3.7). 'KDML 105' brown rice from stored paddy presented a dark yellow colour, indicated by the significant increase in the b^* , a^* and h° values after incubation for 1 month at 45°C (Table 4.3.2 and 4.3.6). Similarly, more yellowness was also observed in 'Suphan Buri 1'. The development of colour in rice during drying or storage is mainly due to the non-enzymatic browning reaction, known as the Maillard reaction (Kongkiattikajorn, 2008). This reaction is significantly accelerated by high temperature (Grass et al. 1989). Our result, especially the b^* value (19.65) (Table 4.3.2), is in agreement with Boonchu et al. (2004). It was presented that the 'KDML 105' brown rice became yellow with a very light brown colour and that the b^* value changed from 19.38 to 19.81 after storage at 25°C for 4 months. This means that the high temperature of 45°C took only 1 month to enhance the changing of the brown rice colour. The lightness (L^* value), however, did not significantly change in brown rice for both cultivars (Table 4.3.2 and 4.3.6). The same incidence was also reported by Boonchu et al. (2004).

Our result also revealed that the yellowness of brown rice increased more in 'KDML 105' compared to 'Suphan Buri 1' (Table 4.3.2 and 4.3.6). This was probably caused by the differences of chemical compositions, which were precursors of the Maillard reaction. The increase of b^* value was due to the increase of brown pigments during storage. Brown pigments provided an index for evaluating the intensity of browning reaction that was caused by the Maillard reaction during storage conditions (Safiah et al., 2008) 'KMDL 105' presented more protein content than 'Suphan Buri 1' (Safiah et al., 2008). It should be concluded that the yellowness of rice would be clearly observed after incubation at high temperature in the rice containing higher protein and glucose

contents in its alueron and endosperm. Grass et al. (1989) described those implications for aged versus non-aged rice as storage temperature simply accelerates the aging process. The colour changes of brown rice occurring during storage caused by non-enzymatic browning. In addition, non-enzymatic browning, husk and bran pigments also appear to contribute to brown rice colour.

5.3.5 Determination to detect brown rice grains

1) Head yield of brown rice grains (%)

In this study, the head yield of whole grains of brown rice was classified as the perfected grains without any defects, *e.g.*, chalky, cracked, etc. (Table 4.3.2 and 4.3.6). ‘KDML 105’ and ‘Suphan Buri 1’ head yield of brown rice statistically increased after incubation at 45°C for 1 month. This suggests that the high temperature treatment would probably encourage some chemical reactions such as lipids, wax, protein and other chemicals to bind together in the alueron layer, a film-like material, resulting in the induced tolerance to the forces used to dehull the paddy. ‘Suphan Buri 1’ exhibited lower head rice yield of whole grains of brown rice after incubation for 1 month (Table 4.3.6). Shilpa et al. (2010) demonstrated that varieties of rice provide different recoveries of whole grains and these criteria can be generally employed to screen for promising varieties. Yield of whole kernel (head) rice varies widely, depending on many factors, such as: variety, grain type, chalkiness, cultural practices, other environmental factors; drying, storing and milling conditions. Yield of total milled rice is also important and is influenced by proportion of hulls and amounts of fine endosperm particles unavoidably included in bran fractions during milling (Luh et al., 1991).

2) Chalky grains (%)

The chalky grains brown rice of both cultivars significantly decreased after incubation. Storage of newly harvested paddy for some periods would enhance the compactness of starch granules and chemical and physicochemical reactions, which induced the compactness of the endosperm including the change of the alueron layer color. The high temperature treatment increased the rate of the reactions. For those incidences, the scattering of light in the stored brown rice kernel at 45°C for 1 month would be different from the initial one, resulting in the declining number of chalky grains.

‘Suphan Buri 1’ exhibited a greater number of chalky grains than ‘KDML 105’ and the change was found to be higher (Table 4.3.2 and 4.3.6). Chalkiness in rice is cultivar specific the variation is also influenced by cultural practices and environment during cultivation (Shilpa et al., 2010; Keawwihar, 2011) Chalky grains are caused by imperfect ripening for morphological reasons or by certain growth conditions (Luh et al., 1991).

3) Cracked grains (%)

The incubation of paddy at 45°C reduced the moisture content in the rice kernel, in which cracking would increase. This was observed in ‘Suphan Buri 1’, but it was not the same for ‘KDML 105’, which significantly decreased (Table 4.3.2 and 4.3.6). This implied that ‘KDML 105’ is more sensitive to the reduction of the moisture content during incubation at 45°C for 1 month leading to the development of cracks in individual kernels. Dong and Zhihuai (2003) stated that the cracked grains were mechanical impacted by overexposure to fluctuation conditions leading to development of cracks in individual kernels.

4) Defect grains (%)

Defects are undesirable physical appearances that develop more from high temperature during storage. It was observed in this study that both cultivars presented the increase of defect grains after incubation for 1 month (Table 4.3.2 and 4.3.6). The defects might have occurred through natural biochemical changes and/or the development of latent damage, which was induced more in the kernels after storage at 45°C for 1 month (IRRI, 2002d). Damage or defect kernels as whole or broken kernels of rice which are distinctly discolored or damaged by water, insects, heat, or any others means (Luh et al., 1991).

5.3.6 Colour of milled rice

Generally, the colour (L^* , a^* , and b^* values) of milled rice is an important criteria for judging its quality and price (Soponronnarit et al., 1998). Our results showed that the incubation temperature of 45°C for 1 month was influential in the chemical reaction, especially the browning reaction leading to the changes of kernel colour. The ‘KDML 105’ milled rice obtained from the paddy incubated at 45°C for 1 month had the L^* , a^* , b^* and h° values of 63.74, 0.28, 11.35 and 88.60 and ‘Suphan Buri 1’ was 71.12, 0.32, 10.43 and 88.28, respectively (Table 4.3.3 and 4.3.7). The L^* value did not change compared to the initial value for both cultivars. Grass et al. (1989) reported that there was no difference in the L^* value of milled rice as storage temperature and time increased. Similarly. Suerap (2009) reported that the L^* , b^* and whiteness values of newly harvested and sun dried ‘Pathum Thani 1’ milled rice were 67.51, 10.26 and 36.88, which were very slightly changed from the initial values after storage for 4 months. Similar results of Chakraverty, (2001) who reported that elevated temperature during drying and/or storage induces more a yellow coloring the rice kernel. This

suggests that the colour of milled rice could be accepted and could not be obviously visualized. The colour of ‘KDML 105’ milled rice, indicated by the a^* , b^* and the h° values was more yellow compared to ‘Suphan Buri 1’. This would be influenced by their original chemical composition.

5.3.7 Determination to detect milled rice grains

1) Head yield of milled rice grains (%)

The whole grains of ‘KDML 105’ and ‘Suphan Buri 1’ milled rice significantly decreased about 5% after incubation. The results disagreed with the increase in the head yield of brown rice. Milling the paddy with low moisture content (9.66 and 7.41% MC for ‘KDML 105’ and ‘Suphan Buri 1’) made it more prone to grain breakage during milling, which led to lower head yield of milled rice (Shilpa et al., 2010). And, high temperature treatment would induce cracking during polishing of the milled rice.

2) Chalky grains (%)

Excessive chalkiness downgrades the quality and reduces milling recovery (IRRI, 2009). The chalkiness of ‘KDML 105’ milled rice was significantly lower compared to the original value, whereas an increase was found in ‘Suphan Buri 1’. Generally, the chalkiness of milled rice is not obviously changed by storage conditions due to as this appearance results directly from their genetics, crop production and weather during cultivation.(IRRI,2009). Pomeranz (1987) described that chalky portions of non-waxy grains were caused by loose arrangement of the cell contents, with air spaces. Starch granules in the chalky portions tend to be spherical and loosely packed. The chalky area contribute to grain breakage during milling, because they are softer than translucent endosperm, which include high resistance to cracking and breakage.

3) Cracked grains (%)

Cracking of individual rice kernels develops more during the postharvest treatment including harvesting, drying, etc. The cracks of 'KDML 105' milled rice were reduced after the 45°C treatment for 1 month. But, in 'Suphan Buri 1', the cracks increased compared to the initial sample (Table 4.3.3 and 4.3.7). The grain size, different reduction of MC (or drying process) and milling process plays a role in cracking. Dong and Zhihuai (2003) described that the cracked grains were mechanical impact and overexposure to fluctuation conditions, which may lead to development of cracks in individual kernels.

4) Defect grains (%)

The defect milled rice of 'KDML 105' and 'Suphan Buri 1' significantly increased after storage for 1 month. The defects of grains due to insects and weather conditions are stimulated by high temperature. Luh et al. (1991), described that the damage or defect kernels of rice were distinctly discolored or defect by water, insects and heat.

5.3.8 Amylose content (%)

The amylose content of rice is considered to be one of the most important constitutional indices of rice cooking quality, as it determines the hardness of cooked rice, gloss of the final product and the rice-water ratio. The amylose content of 'KDML 105' and 'Suphan Buri 1' increased after storage for 1 month (Table 4.3.4 and 4.3.8), suggesting that the temperature at 45°C for 1 month probably induced the degradation of amylopectin resulting to the in higher amylose content in the kernels. Therefore, aged rice could be preceded by incubation the paddy at 45°C for 1 month. However, Kongkiatikhajornet et al. (2004) reported that the storage of paddy at 25 or 37°C for 7 months did not impact the amylose content of 'KDML 105'.

5.3.9 Elongation ratio (mm)

The elongation ratio of cooked rice is one of the eating quality characteristics. It significantly increased after storage and the elongation ratio of cooked rice was greater in the higher amylose content rice (Singih et al., 2000). The increase of the elongation ratio had a strong relation with the compact starch granules and chemical and physiochemical reactions during storage (Juliano and Perez, 1983). Both rice cultivars presented an increased elongation ratio of cooked rice after incubation at 45°C for 1 month (Table 4.3.4 and 4.3.8). Our results showed that the elongation of cooked rice was able to be induced by high temperature treatment. Kernel elongation is a physical phenomenon that is induced by high temperature treatment (Sarathe et al., 1986).

5.3.10 Water absorption (%)

The water absorption for both cultivars increased (Table 4.3.4 and 4.3.8) compared to their original samples. The increase was obvious in ‘Supahn Buri 1’. The result indicated that the high temperature and cultivar affected the water absorption of cooked rice during cooking. Rice stored for about 4–6 months absorbed more water compared to newly harvested rice (Luh et al. 1991). Rice undergoes changes during the first 3–4 months after harvest particularly kept above 15°C, when stored paddy or rough, brown and milled form while the water absorption more increased during cooking. The water absorption of the grain during cooking is also directly affected by amylose content (Jocelyn et al., 1991). Waxy rice, whose starch is all amylopectin, expands the least during cooking, and its cooked grains have a high bulk density compared to the cooked high-amylose rice, which has extreme volume expansion (Jocelyn et al., 1991). ‘Suphan Buri 1’ contains higher amylose according that its water absorption would be higher. Chapman et al. (1996) described that high amylose and aged rice generally

absorbs more water and expands more during cooking at 99°C in excess water, than low amylose rice.

5.3.11 Texture of cooked rice hardness and stickiness (N)

Hardness and stickiness were evaluated and it was revealed that the hardness of ‘KDML 105’ and ‘Suphan Buri 1’ cooked rice was significantly increased. In contrast, the stickiness was reduced by high temperature for 1 month. The texture of cooked rice grains become harder and less sticky than cooked fresh rice as measured by texture analysis (Juliano and Perez (1983). Similar results occurred in aged rice reported by Noomhorm et al. (1997). ‘KDML 105’ cooked rice exhibited a softer texture compared to ‘Suphan Buri 1’. The hardness of cooked rice shows a positive correlation with amylose content. And, the stickiness of cooked rice is correlated negatively with amylose content (Jocelyn et al., 1991).

Our results suggest that the characteristics of rice including the physical property of paddy, brown and milled rice, amylose content and cooked rice qualities were induced by incubation for 1 month at 45°C. And, their qualities were similar to the rice aged for 4–6 months. However, the head yield of milled rice was negatively impacted; the yield was reduced about 5 and 7% for ‘KDML 105’ and ‘Supahn Buri 1’, respectively. On the other hand, the yield of brown rice increased. These 2 important characteristics probably would be concerned for trading.