

CHAPTER IV

DETERMINATION OF DRYING TIME

Drying time is a major drying parameter affecting the dried product quality variation. Therefore, the drying time for each dried product type is determined in this chapter. The outline of this chapter is organized into five sections. In Section 4.1 to 4.4, experimental results of paddy rice, cassava chip, tobacco, and longan are explained and discussed respectively. After finding the drying time, all experimental results are concluded and summarized in Section 4.5.

4.1 Experimental Results of Paddy Rice

Paddy rice is transferred to the drying process with three drying phases. Firstly, paddy rice is heated within heating phase. Secondly, heated paddy rice is dried with a constant drying rate phase. Finally, dried paddy rice from the second phase is dried again with falling drying rate phase. The experimental results are shown as following three drying phases as heating, drying with a constant drying rate phase, and drying with falling rate phase.

4.1.1 Heating Phase

Paddy rice is heated with varying levels of the heating temperature at 55, 60, and 65°C. Within each varying of the heating temperature level, heating time is specified at 40 seconds to determine the heating period time. The results are shown as Figure 4.1.

From the Figure 4.1, the moisture content is changed after heating within 30 seconds. All moisture contents from all heating temperature levels are reduced continuously. After heating within 40 seconds, the moisture content from heating at 55°C is 26.8% w.b., the moisture content from heating at 60°C is 26.5%

w.b., and the moisture content from heating with 65°C is 26.4% w.b. From these results, paddy rice should be heated within 30 seconds.

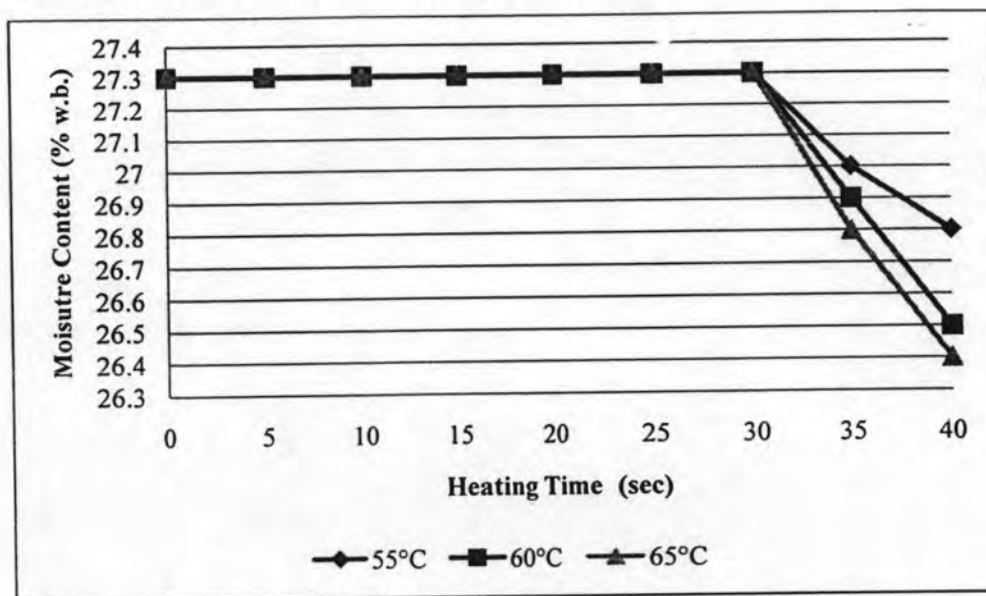


Figure 4.1 Heating result for determining heating time of paddy rice

4.1.2 Drying with a Constant Rate Phase

After paddy rice is heated in the first drying phase, it is dried in order to reduce the moisture content to 18.0% w.b. The experiments are conducted with varying levels of the drying temperature at 110, 120, and 130°C. Within each varying of the drying temperature level, drying time is specified at 10 minutes to determine the drying period time. The results are shown as Figure 4.2.

From the Figure 4.2, the moisture content is reduced continuously with a constant drying rate. From all drying temperature levels, paddy rice which is dried within 5 minutes can be reduced the moisture content to the target as 19.0% w.b. Therefore, paddy rice from heating phase should be dried within 5 minutes of the second drying phase.

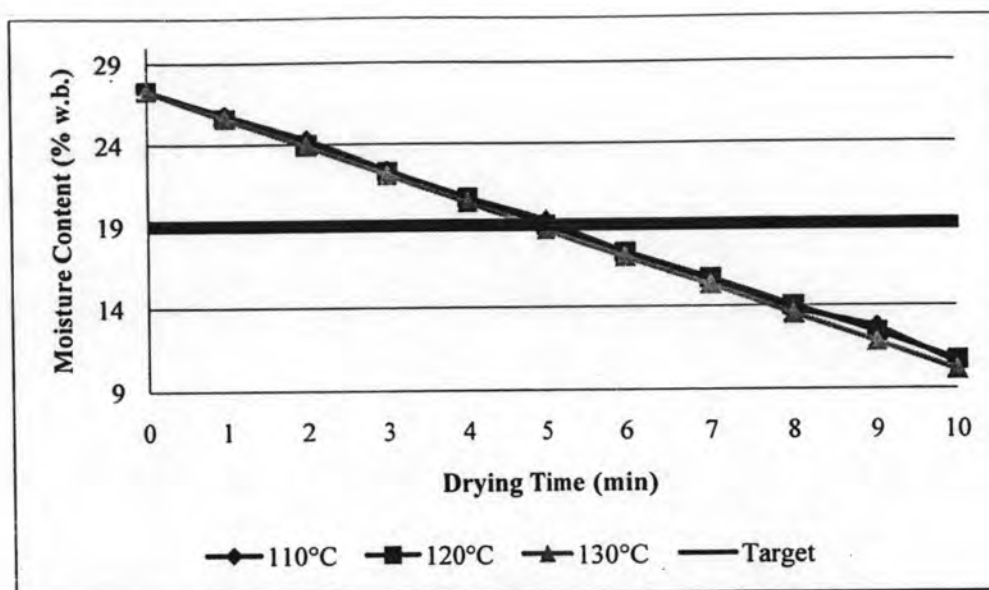
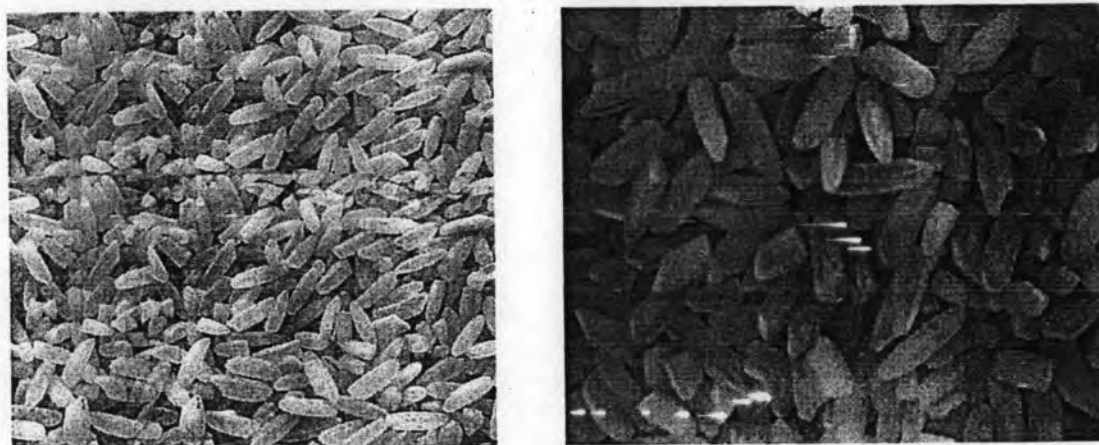


Figure 4.2 Drying result for determining drying time of paddy rice within a constant drying rate phase

From the Figure 4.2, heated paddy rice can be dried to the moisture content at 14.0% w.b. as the quality target within eight minutes. Although this period time can be used to reduce the moisture content to the quality target, dried paddy rice from this period is smelly. Moreover, paddy rice is more cracked than drying with falling rate phase (Figure 4.3).



(a) from drying with a constant rate phase (b) from drying with falling rate phase

Figure 4.3 Comparison cracked paddy rice from drying with between a constant drying rate phase and falling drying rate phase

4.1.3 Drying with Falling Rate Phase

After paddy rice is dried in the second drying phase, it is dried again in order to reduce the moisture content to 14.0% w.b. within the last drying phase. The experiments are conducted with varying levels of the drying temperature at 55, 60, and 65°C. Within each varying of the drying temperature level, drying time is specified at 15 hours to determine the drying period time. The results are shown as Figure 4.4.

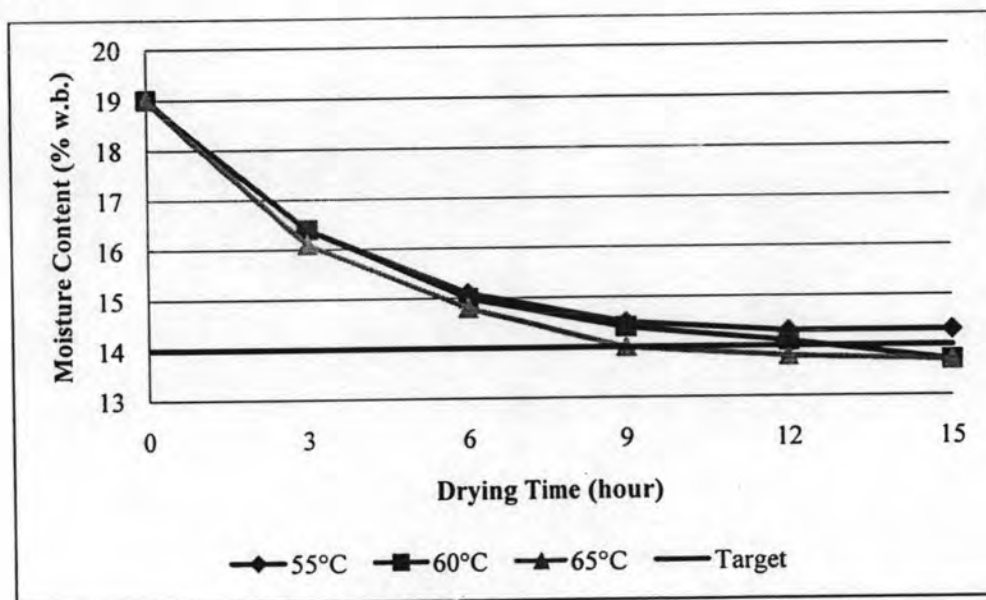


Figure 4.4 Drying result for determining drying time of paddy rice within falling drying rate phase

From the Figure 4.4, the moisture content is reduced continuously with falling drying rate. From drying temperature levels at 55 and 60°C, paddy rice which is dried within 12 hours can be reduced the moisture content nearing to the target as 14.0% w.b. While, paddy rice dried with temperature level at 65°C can be reduced the moisture content to the target within 9 hours, but its smell is not accepted by the manufacturer. Therefore, drying time of falling drying rate phase should be 12 hours.

4.2 Experimental Results of Cassava Chip

Cassava chip is transferred to the drying process with three drying phases. Firstly, cassava chip is heated within heating phase. Secondly, heated cassava chip is dried with a constant drying rate phase. Finally, dried cassava chip from the second phase is dried again with falling drying rate phase. The experimental results are shown as following three drying phases as heating, drying with a constant drying rate phase, and drying with falling rate phase.

4.2.1 Heating Phase

Cassava chip is heated with varying levels of the heating temperature at 90, 100, and 110°C. Within each varying of the heating temperature level, heating time is specified at 10 minutes to determine the heating period time. The results are shown as Figure 4.5.

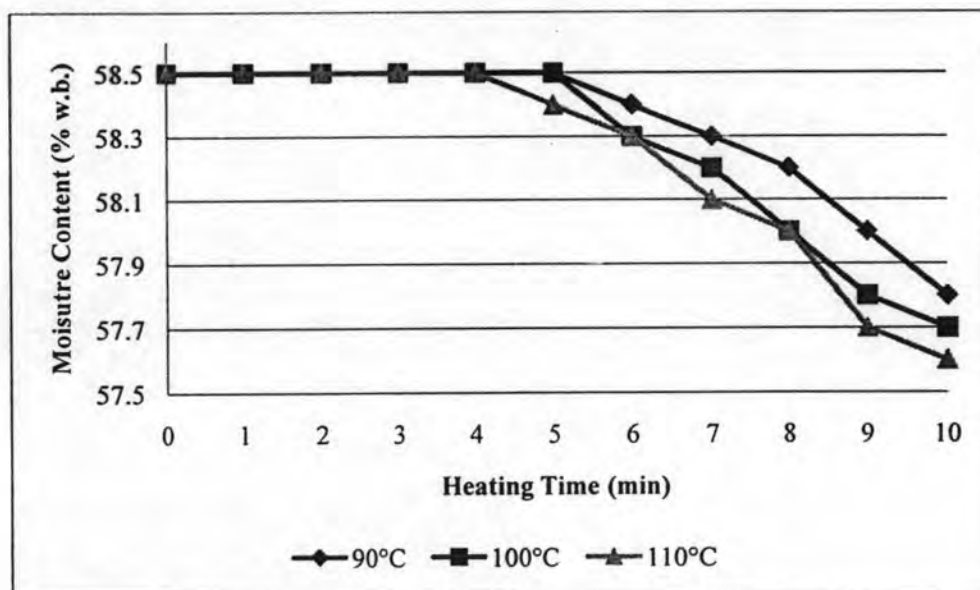


Figure 4.5 Heating result for determining heating time of cassava chip

From the Figure 4.5, the moisture content is changed after heating within 5 minutes. All moisture contents from all heating temperature levels are reduced continuously. After heating within 10 minutes, the moisture content from heating at 90°C is 57.8% w.b., the moisture content from heating at 100°C is 57.7%

w.b., and the moisture content from heating with 110°C is 57.6% w.b. From these results, cassava chip should be heated within five minutes.

4.2.2 Drying with a Constant Rate Phase

After cassava chip is heated in the first drying phase, it is dried in order to reduce the moisture content to 30.0% w.b. The experiments are conducted with varying levels of the drying temperature at 90, 100, and 110°C. Within each varying of the drying temperature level, drying time is specified at 30 minutes to determine the drying period time. The results are shown as Figure 4.6.

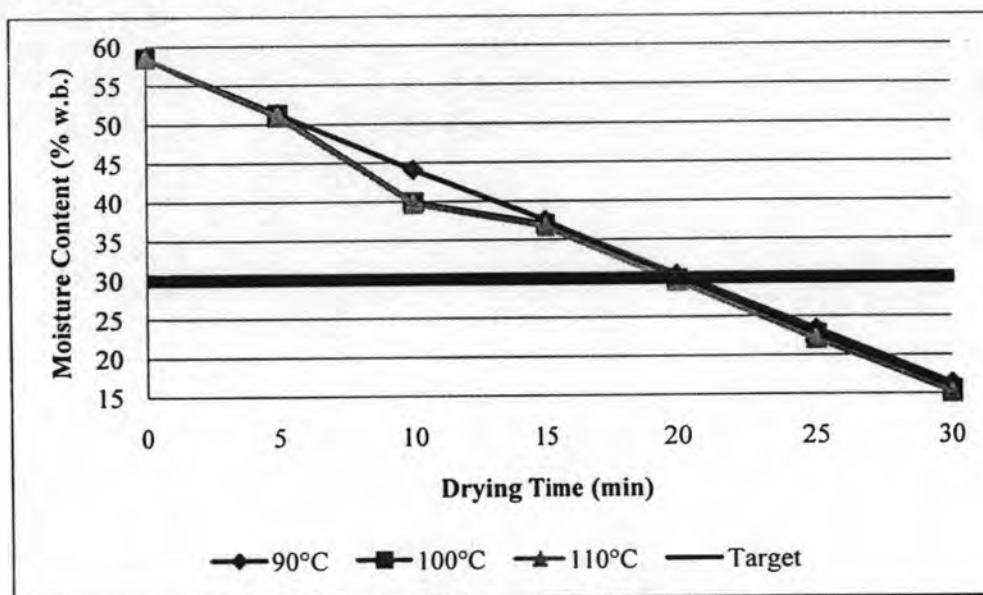


Figure 4.6 Drying result for determining drying time of cassava chip within a constant drying rate phase

From the Figure 4.6, the moisture content is reduced continuously with a constant drying rate. From all drying temperature levels, cassava chip which is dried within 20 minutes can be reduced the moisture content to the target as 30.0% w.b. Therefore, cassava chip from heating phase should be dried within 20 minutes of the second drying phase.

4.2.3 Drying with Falling Rate Phase

After cassava chip is dried in the second drying phase, it is dried again in order to reduce the moisture content to 14.0% w.b. within the last drying phase. The experiments are conducted with varying levels of the drying temperature at 90, 100, and 110°C. Within each varying of the drying temperature level, drying time is specified at 20 minutes to determine the drying period time. The results are shown as Figure 4.7.

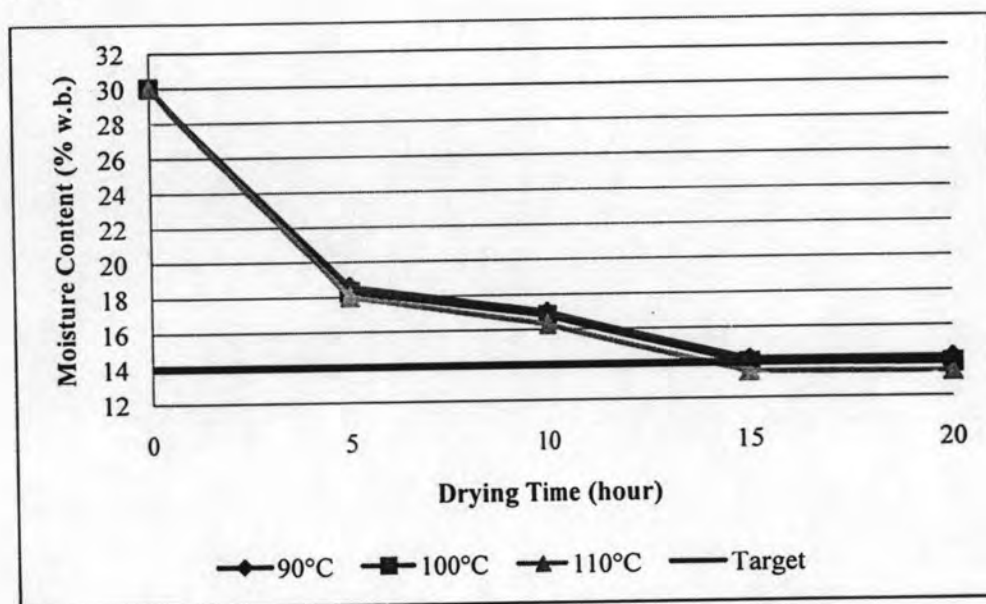


Figure 4.7 Drying result for determining drying time of cassava chip within falling drying rate phase

From the Figure 4.7, the moisture content is reduced continuously with falling drying rate. From all drying temperature levels, cassava chip which is dried within 15 minutes can be reduced the moisture content nearing to the target as 14.0% w.b. Therefore, drying time of falling drying rate phase should be 15 minutes. Moreover, cassava chip which is dried with these drying time can be illustrated as Figure 4.8.



Figure 4.8 Dried cassava chip

4.3 Experimental Results of Tobacco

Tobacco is transferred to the drying process with three drying phases. Firstly, tobacco is heated within heating phase. Secondly, heated tobacco is dried with a constant drying rate phase. Finally, dried tobacco from the second phase is dried again with falling drying rate phase. The experimental results are shown as following three drying phases as heating, drying with a constant drying rate phase, and drying with falling rate phase.

4.3.1 Heating Phase

Tobacco is heated with varying levels of the heating temperature at 55, 60, and 65°C. Within each varying of the heating temperature level, heating time is specified at five minutes to determine the heating period time. The results are shown as Figure 4.9.

From the Figure 4.9, the moisture contents from heating with the temperature levels at 55 and 60°C are changed after heating within three minutes, while the moisture content from heating with the temperature level at 65°C is changed after heating with two minutes. However, tobacco should be heated within three minutes.

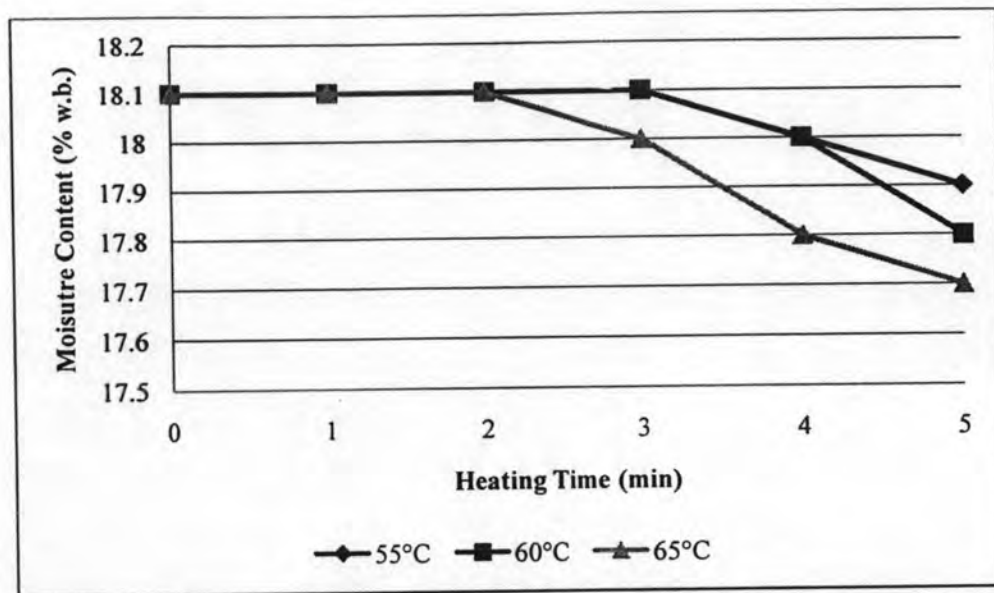


Figure 4.9 Heating result for determining heating time of tobacco

4.3.2 Drying with a Constant Rate Phase

After tobacco is heated in the first drying phase, it is dried in order to reduce the moisture content to 14.0% w.b. The experiments are conducted with varying levels of the drying temperature at 60, 65, and 70°C. Within each varying of the drying temperature level, drying time is specified at 20 minutes to determine the drying period time. The results are shown as Figure 4.10.

From the Figure 4.10, the moisture content is reduced continuously with falling drying rate. From all drying temperature levels, tobacco which is dried within 10 minutes can be reduced the moisture content nearing to the target as 14.0% w.b. Therefore, drying time of falling drying rate phase should be 10 minutes.

However, from the Figure 4.10, heated tobacco can be dried to the moisture content at 12.5% w.b. as its quality target within 14 minutes. Although this period time can be used to reduce the moisture content to the quality target, color of the dried tobacco from this period is not accepted by the customers. Its color shown as Figure 4.11(a) is darker than dried tobacco from drying with falling drying rate phase shown as Figure 4.11(b).

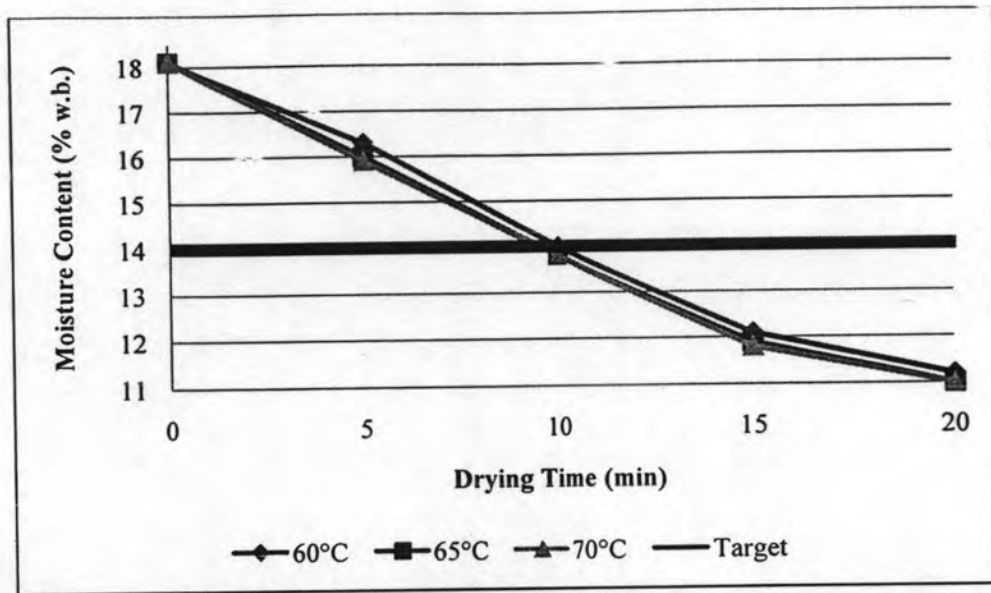
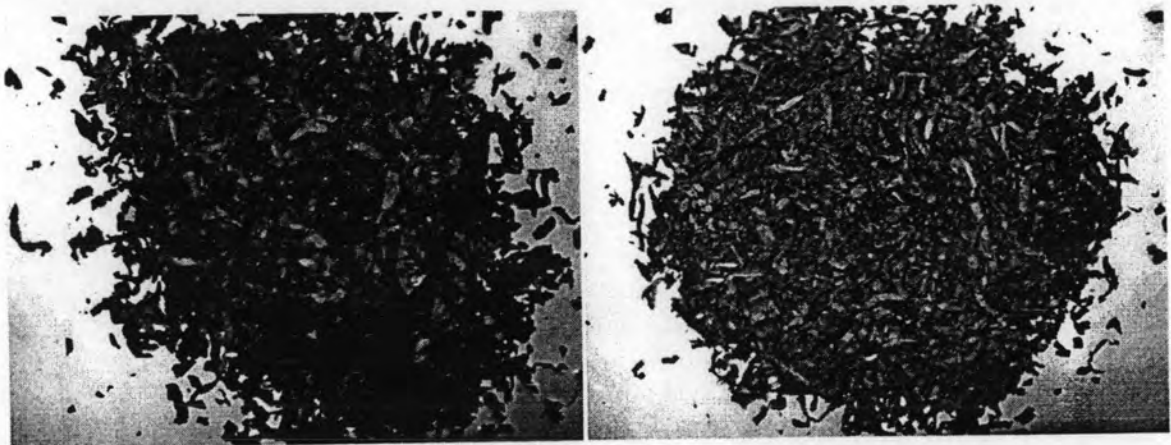


Figure 4.10 Drying result for determining drying time of tobacco within a constant drying rate phase



(a) from drying with a constant rate phase (b) from drying with falling rate phase

Figure 4.11 Comparison of tobacco's color from drying with between a constant drying rate phase and falling drying rate phase

4.3.3 Drying with Falling Rate Phase

After tobacco is dried in the second drying phase, it is dried again in order to reduce the moisture content to 12.5% w.b. within the last drying phase. The experiments are conducted with varying levels of the drying temperature at 45, 50, and 55°C. Within each varying of the drying temperature level, drying time is specified at 10 minutes to determine the drying period time. The results are shown as Figure 4.12.

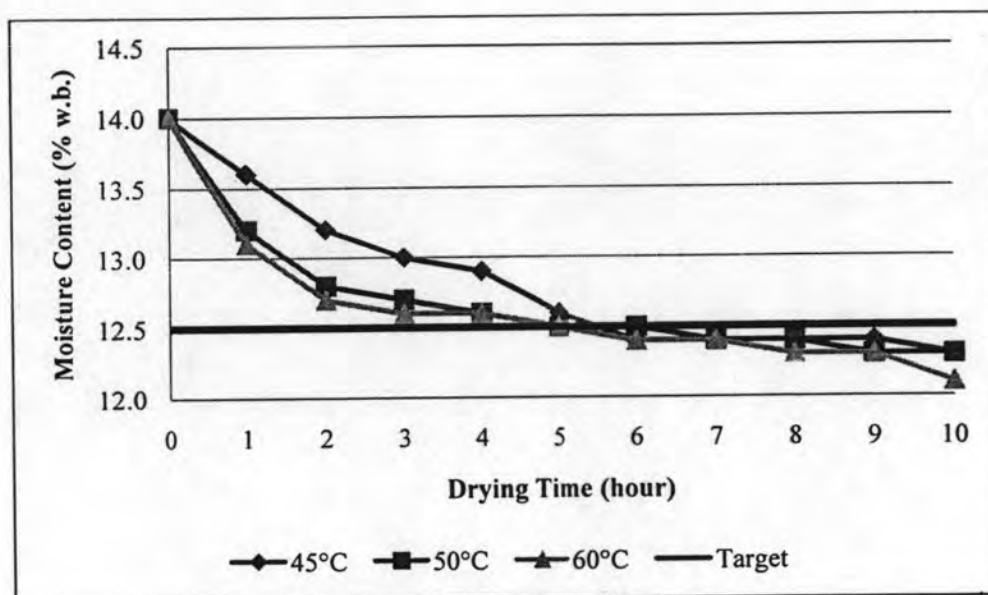


Figure 4.12 Drying result for determining drying time of tobacco within falling drying rate phase

From the Figure 4.12, the moisture content is reduced continuously with falling drying rate. From all drying temperature levels, tobacco which is dried within five minutes can be reduced the moisture content nearing to the target as 12.5% w.b. Therefore, drying time of falling drying rate phase should be five minutes.

4.4 Experimental Results of Longan

Longan is transferred to the drying process with three drying phases. Firstly, longan is heated within heating phase. Secondly, heated longan is dried with a constant drying rate phase. Finally, dried longan from the second phase is dried again with falling drying rate phase. The experimental results are shown as following three drying phases as heating, drying with a constant drying rate phase, and drying with falling rate phase.

4.4.1 Heating Phase

Longan is heated with varying levels of the heating temperature at 70, 75, and 80°C °C. Within each varying of the heating temperature level, heating time is specified at 18 hours to determine the heating period time. The results are shown as Figure 4.13.

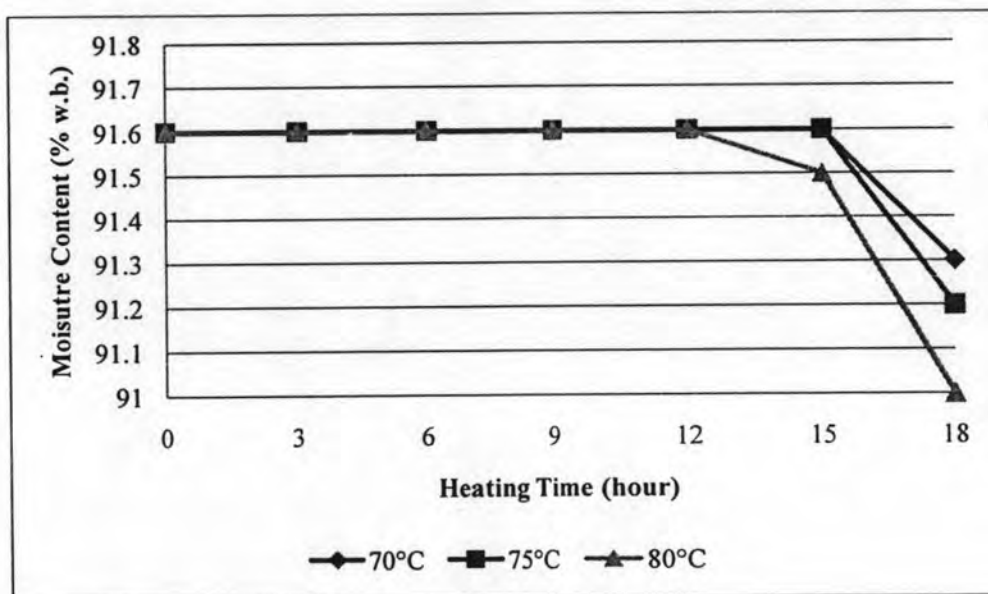


Figure 4.13 Heating result for determining heating time of longan

From the Figure 4.13, the moisture contents from heating with the temperature levels at 70 and 75°C are changed after heating within 15 hours, while the moisture content from heating with the temperature level at 80°C is changed after

heating with 12 hours. However, from the results, longan should be heated within 15 hours.

4.4.2 Drying with a Constant Rate Phase

After longan is heated in the first drying phase, it is dried in order to reduce the moisture content to 73.0% w.b. The experiments are conducted with varying levels of the drying temperature at 80, 85, and 90°C. Within each varying of the drying temperature level, drying time is specified at 18 hours to determine the drying period time. The results are shown as Figure 4.14.

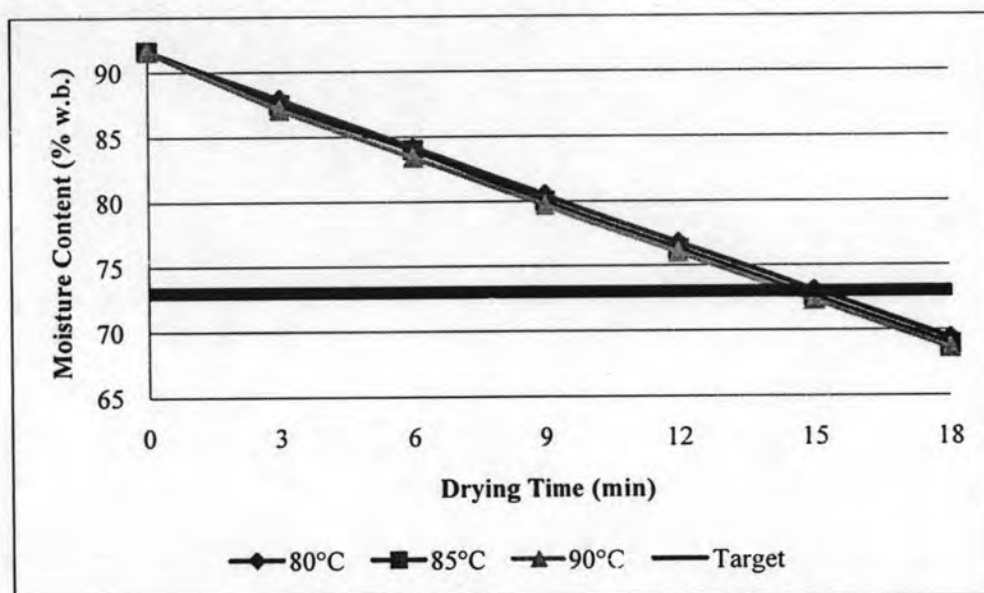


Figure 4.14 Drying result for determining drying time of tobacco within a constant drying rate phase

From the Figure 4.14, the moisture content is reduced continuously with falling drying rate. From all drying temperature levels, longan which is dried within 15 hours can be reduced the moisture content nearing to the target as 73.0% w.b. Therefore, drying time of falling drying rate phase should be 15 hours.

4.4.3 Drying with Falling Rate Phase

After longan is dried in the second drying phase, it is dried again in order to reduce the moisture content to 18.0% w.b. within the last drying phase. The experiments are conducted with varying levels of the drying temperature at 80, 85, and 90°C. Within each varying of the drying temperature level, drying time is specified at 12 hours to determine the drying period time. The results are shown as Figure 4.15.

From the Figure 4.15, the moisture content is reduced continuously with falling drying rate. From all drying temperature levels, longan which is dried within 10 hours can be reduced the moisture content nearing to the target as 18.0% w.b. Therefore, drying time of falling drying rate phase should be 10 hours. Moreover, dried longan from these drying times is shown as Figure 4.16.

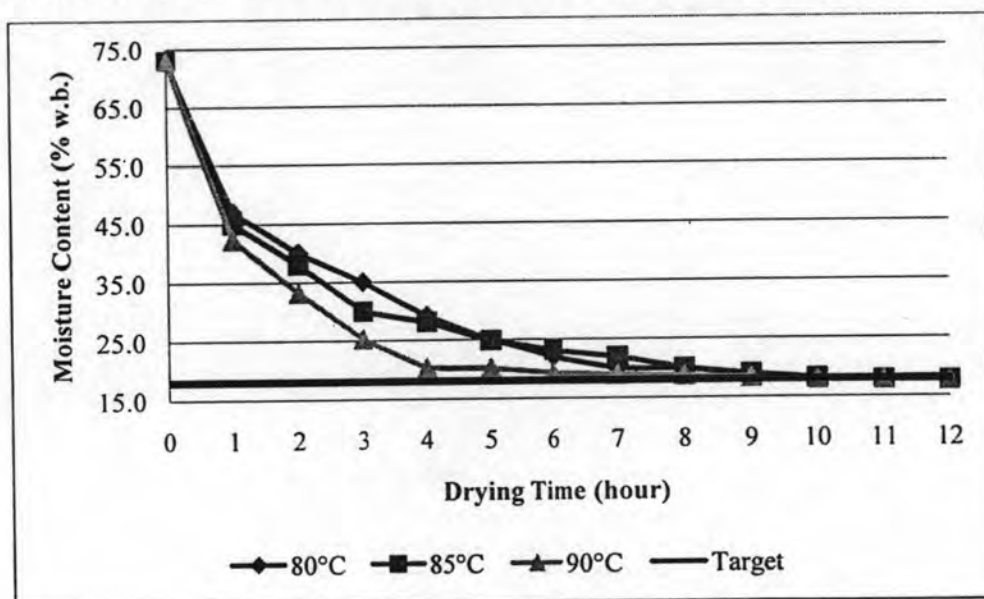


Figure 4.15 Drying result for determining drying time of longan within falling drying rate phase

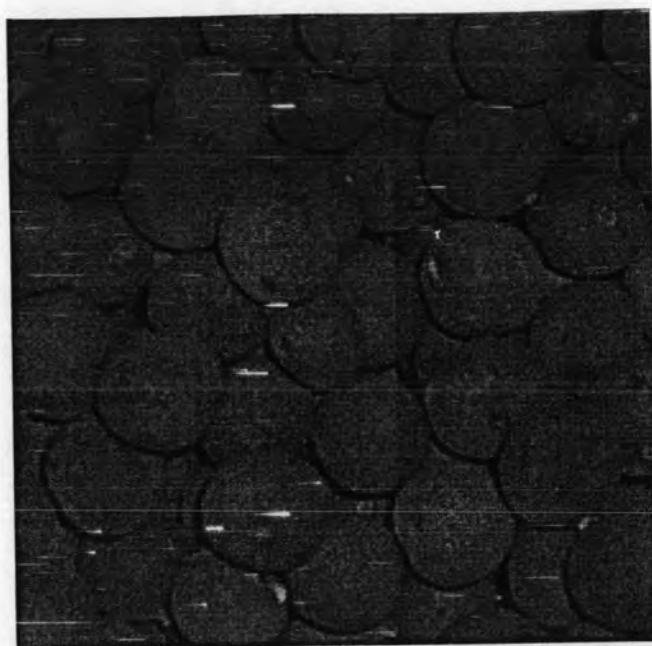


Figure 4.16 Dried longan

4.5 Conclusion

The aims of this chapter are to determine the drying time for drying the product within each drying phase. Drying temperature is varied at three levels for each drying phase. From all of experimental results, they are concluded and summarized in Table 4.1.

Table 4.1 Summary of drying time for each drying phase

Product	Optimal Drying Time for Each Drying Phase		
	Heating Phase	Drying with a Constant rate Phase	Drying with Falling Rate Phase
Paddy rice	30 seconds	5 minutes	12 hours
Cassava chip	5 minutes	20 minutes	15 minutes
Tobacco	3 minutes	10 minutes	5 minutes
Longan	15 hours	15 hours	10 hours