Effective Factors on Equilibrium Relative Humidity of Agricultural Products[1]

Chia-Chung Chen and Chih-Tsu Tsao[2]

Abstract : The ERH step-by-step determinating technique was performed to measure the desorption and adsorption properties of seven agricultural products dried with different temperatures to compare the factors affecting ERH/EMC properties. The results indicated that the effect of drying temperature on ERH/EMC properties was significant for rough rice, corn kernels, and corn cobs, however, the effect of these properties is not obvious for soybeans and red beans. The hysteresis of corn kernels was reduced by the drying temperatures, however, those of rough rice was not affected by drying treatments. Little moisture hysteresis was appeared in soybeans and red beans. Comparing of this present study with previously published data for agricultural products, there was a good agreement among ERH/EMC data from different sources for the products of rough rice, brown rice, corn cobs and red beans. The inconsistent results were found for soybeans. The serious diversity of the scattering data indicated those properties of corn kernels and sorghum kernels were affected by different factors.

Key words : Equilibrium Relative Humidity.

INTRODUCTION

Data relating equilibrium relative humidity (ERH) ,equilibrium moisture content (EMC) , and temperature are necessary to design postharvest systems for agricultural products. The equilibrium moisture content for the adsorption and desorption process did not have the same values. The difference is called the hysteresis effect. Desorption property was mainly used in drying process. Adsorption property was applied in storage. The hysteresis had the significant effect on the chemical reaction of foodstuffs.

Available isotherm sorption data sets for grains and oil seeds are inconsistent. Few attempts have made to compare and explain the effects of variety, methodology, drying treatment, and other factors. Recently, the ERH determinating method had been developed to measure the ERH/EMC data accurately within a short time. This technique provides a new and promising way to compare the factors affecting the ERH/EMC properties.

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Pfost et al. [26] compared major factors affecting EMC data for corn kernels from several sources. They encountered great difficulty when trying to summarize data from various sources using different methods. They then suggested enther pooling the results of several investigators, or having one investigator test a wide range of varieties.

Neuber [24] reviewed the twenty-seven published reports on corn isotherms. The important factors related to the EMC values are : 1) composition of material, oil, ash, fiber, protein and starch ; 2) characteristics of the materials, variety, and size ; 3) treatment of sample, drying temperature, drying method, rewetting method ; 4) determination method for m. c. and RH ; 5) method of equilibration ; 6) control of RH and temperature. Neuber then suggested that a standard method should be established as soon as possible for the determination of sorption isotherms. In order to arrive at a comparable result, it is also necessary to identify the factors which influence the equilibrium moisture curves.

The ERH properties of five oilseeds with different oil content were reported by Pixton et al. [28]. The oilseeds with higher oil content adsorbed less water at the same RH value.

The effects of variety, harvest year, and maturity have not shown consistent results among several research studies. Pfost et al.[26] used a statistical technique to test sorption isotherm data obtained from English and U. S. maize. They concluded that the two varieties used were significantly different.

Pixton and Henderson [30] compared EMC data of five varieties of Canadian wheat and two varieties of rapeseed. They found that the difference in the EMC/ERH relations of wheat and rapeseed were small and significant only at low moisture contents.

Form the research on EMC properties of corn cobs, White et al.[38] concluded that no significant difference existed in desorption ERH values for three selected corn varieties.

Comparing the ERH data of soybeans with the previously reported by EMC determinating method, Osborn et al.[25] concluded that the obvious difference exist between the two studies. They explained the results by the different test varieties or samples, or the determinating method.

Mazza et al.[23] have reported the sorption isotherms of five cultivars of flax seed. They found the cultivar and determinating method had no significant effect on the sorption properties of flax seed.

Tuite and Foster[36] studied the effect of drying treatment on the ERH properties and noticed that the ability to absorb moisture progressively decreased with increasing drying temperature.

In a study of the drying temperature effect on the EMC data of dried beef, Oglesias and Chirife[17] found the higher the drying temperature the lower the sorption capacity of dried beef.

From the study of ERH properties of corn kernels, Chen and Morey[5] reported that the isotherms of this product were significantly different ofr varieties and harvest years. The water adsorbing ability of yellow-dent corn dropped as the drying temperature increases.

The objectives of this study were to :

1. Determine the EMC/ERH relationships of seven agricultural products treated with five

different temperatures.

2. Determine the effects of factors such as history and drying treatment on the ERH property.
3. Compare the sorption isotherms of these seven experimautal products with previous published data.

MATERIALS AND METHODS

Materials

Seven agricultural products, rough rice, brown rice, corn kernels, corn cobs, sorghum kernels, and red beans grown at the Taiwan Agricultural Research Institute, Taichung, Taiwan, in 1991 and 1992 were used in this study. The samples of brown rice was processed from rough rice. For the samples treated by lower temperature (25°C) , the desorption sample was dehydrated at different RH environment made by the saturated salty solutions to reach the required moisture contents. The adsorption samples, its initial m. c. was about 3% dry basis, rewetted by adding water to predetermined moisture content. For the samples of higher drying temperature (50°C) , desorption samples were dried by the heated air to the predetermined m. c.. The adsorption samples, with initial m. c. about 3% d. b., were rewetted by adding water.

All samples were sealed in plastic containers and stored in freezer at 3°C for six weeks to ensure the moisture equilibria.

ERH Method

The determinating method of the step-by-step ERH technique is similar to that used by Chen and Morey[5]. Samples in airtight containers at a known m. c. were placed in a temperature control chamber. The temperature and relative humidity sensors ere inserted to the containers. As the experiment began, these containers placed in the chamber were maintained at 5°C. When the temperature and relative humidity within the containers reached the equilibrated state, the RH and temperature values for RH sensors were recorded by the data logger. The chamber temperature was then adjusted to next temperature level. All the ERH values were determinated at five temperatures (5, 15, 25, 35 and 50 °C) . The readings of RH sensors were transformed by its calibration equations.

RH sensor

The Rotronic I-100 Ttansmitter was used in these tests. All sensors were calibrated by using several saturated salt solutions. The adequate calibration equations were established by the same statistical method used by Chen and Tsao[6].

After finishing the ERH experiments, three grain samples were taken out from each container to measure their moisture contents. Moisture contents were determined by oven drying method[2].

Data analysis

The EMC/ERH data for these agricultural products were analyzed by four equations. The program NONLIN weitten in QBASIC language was applied to evaluate the fitting-agreement of ERH models.

RESULTS AND DISCUSSIONS

Rough rice

The sorption isotherms of 25°C for four treatments are shown in Fig. 1. Hysteresis existed over the entire range. The treatment temperatures significantly reduced water holding ability. At the 60% RH environment, the m. c. of desorption curves dried at 25°C is 2.4% higher than those of adsorption isotherms dried at 50°C. For two drying treatments, the effect of hysteresis is similar and the different m. c. nearly 0.5 to 1.0%. The similar results could be found from the sorption data of paddy rice[32]. The comparison of desorption data

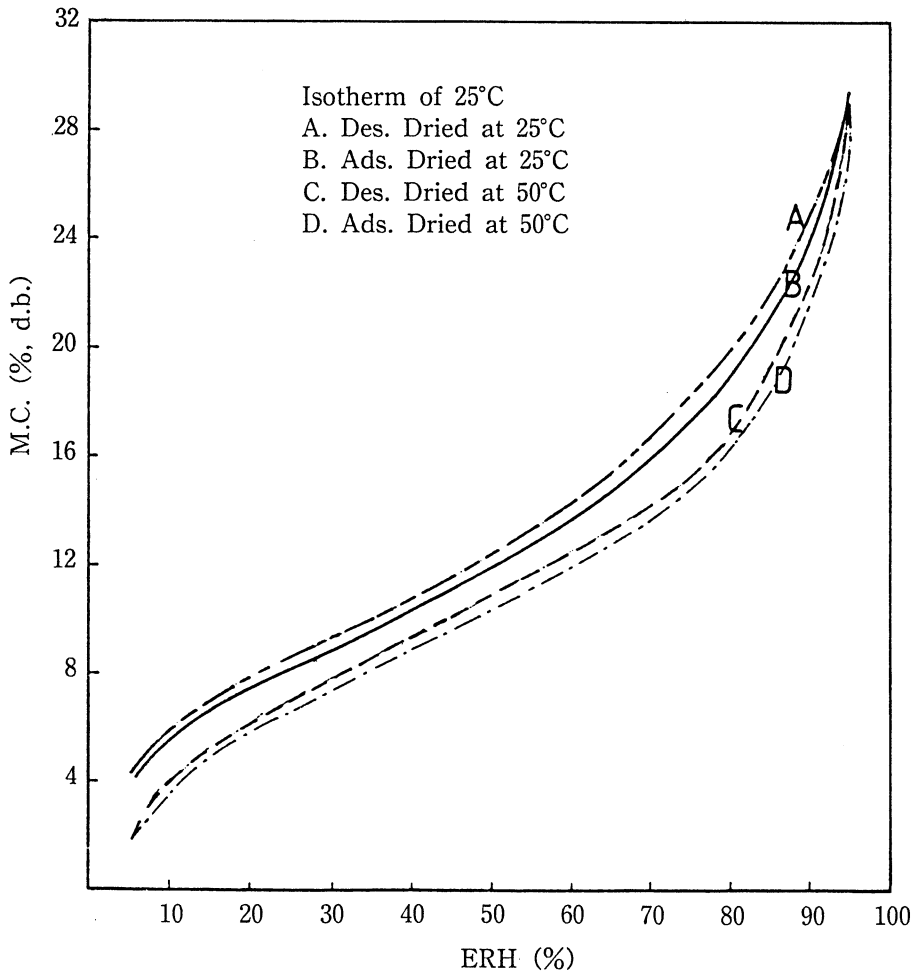


Fig. 1. Effect of the drying temperatures on the sorption isotherm of rough rice at 25° C.

of this study with three countries USA[40], Japan[22],and Australia[32] are shown in Fig. 2. The shape of isotherms for Taiwan's variety is very close to other countries. The deviations of four isotherms are within 0.8% m. c. at the same RH environment, however, the water reducing ability of isotherms dried at 50°C is nearly 3.0%. The ERH/EMC properties for the products of USA and Japan were determined by the traditional EMC method. The sorption isotherms for Australia rice was measured by dewpoint temperatures. The results indicated that the variety and determinating techniques have little effect on the ERH/EMC properties of rough rice. The drying temperature was the only significant dominant factors.

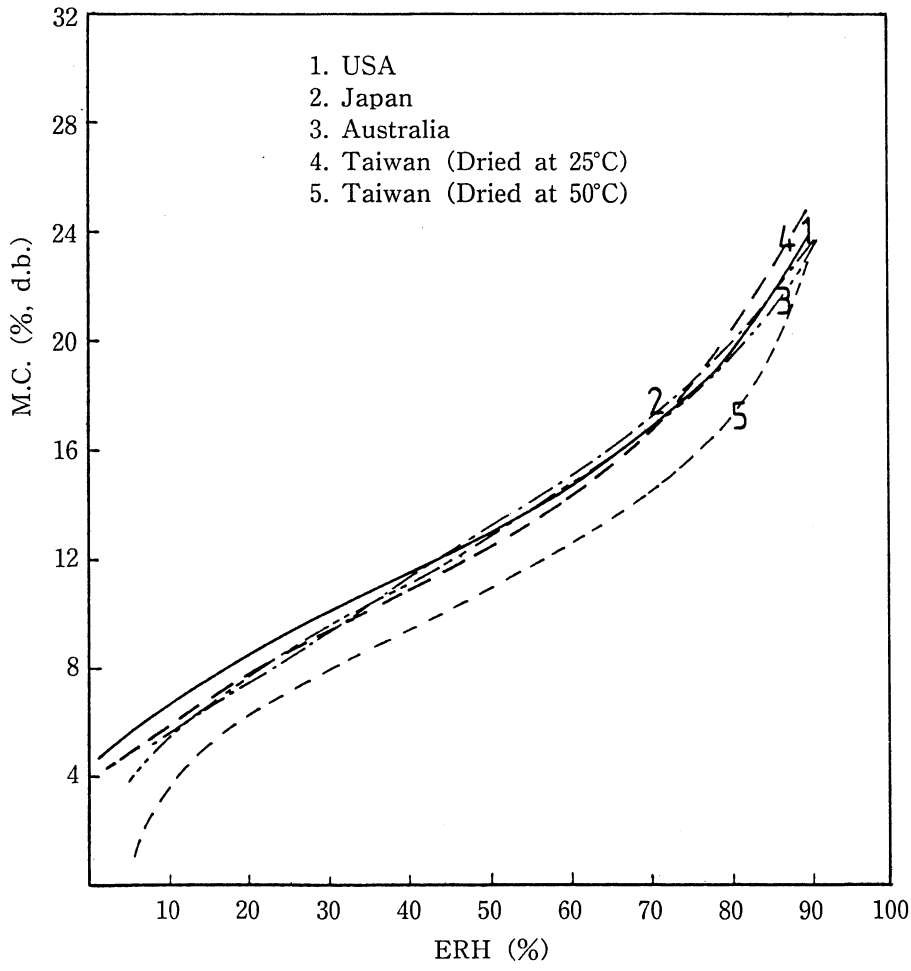


Fig. 2. Comparison of desorption isotherms of rough rice with previously published data at 25° C.

The ERH/EMC properties for present research at 25°C are compared with several sorption data sets taken from different literature of unspecified cultivars. The results are shown in Fig. 3. There was very good agreement among data. It is reasonable to establish the universal ERH model for rough rice.

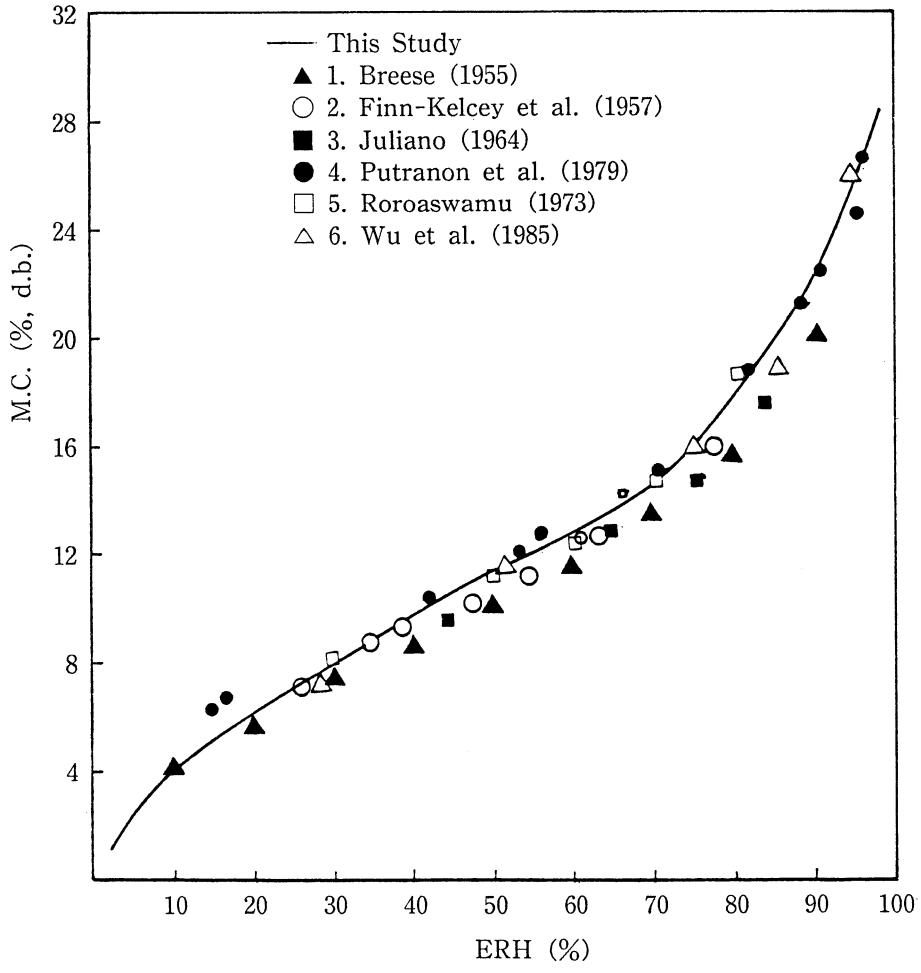


Fig. 3. Comparison of adsorption isotherms of rough rice with previously published data at 25° C.

Brown rice

The EMC data from previously literature compared with this present study are shown in Fig. 4. No significant difference could be found. The drying temperature had the significant effect on the ERH/EMC properties. Cultivar, growth location, and determinatig technique seems only have little effect the ERH properties.

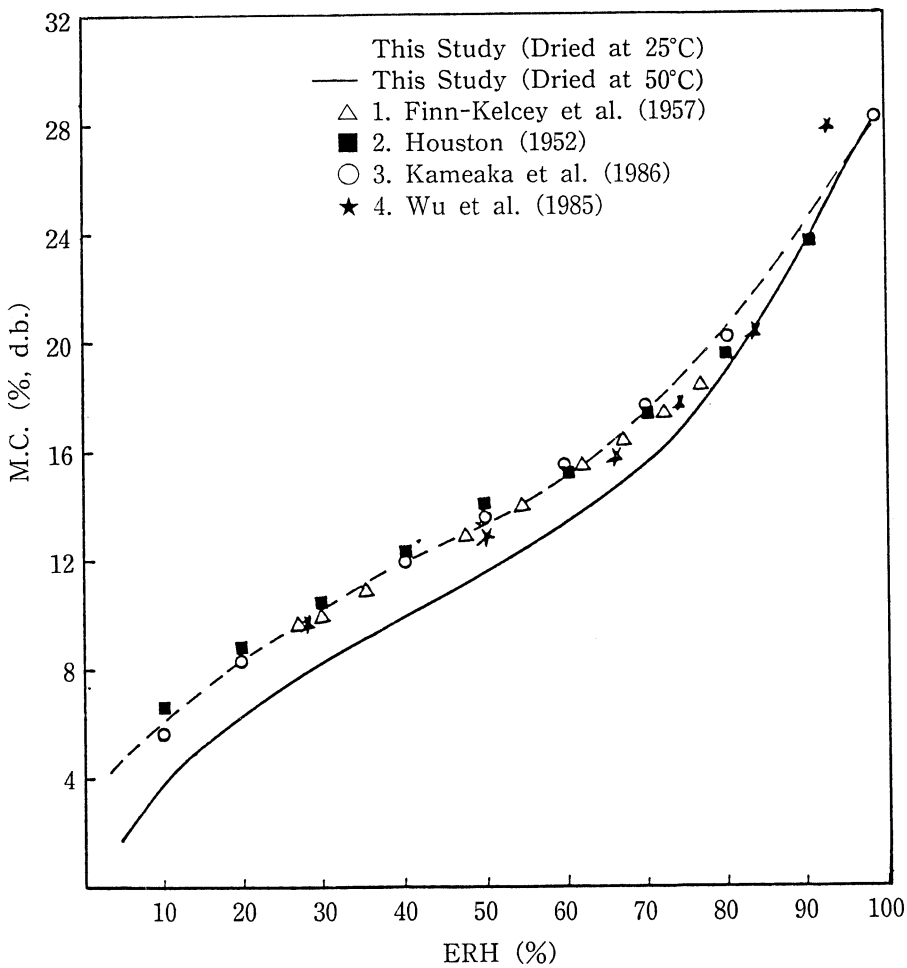


Fig. 4. Comparison of adsorption isotherms of brown rice with previously published data at 25° C.

Corn kernels

The effect of drying temperatures are shown in Fig. 5. The water holding ability and hysteresis reduced by the drying temperature.

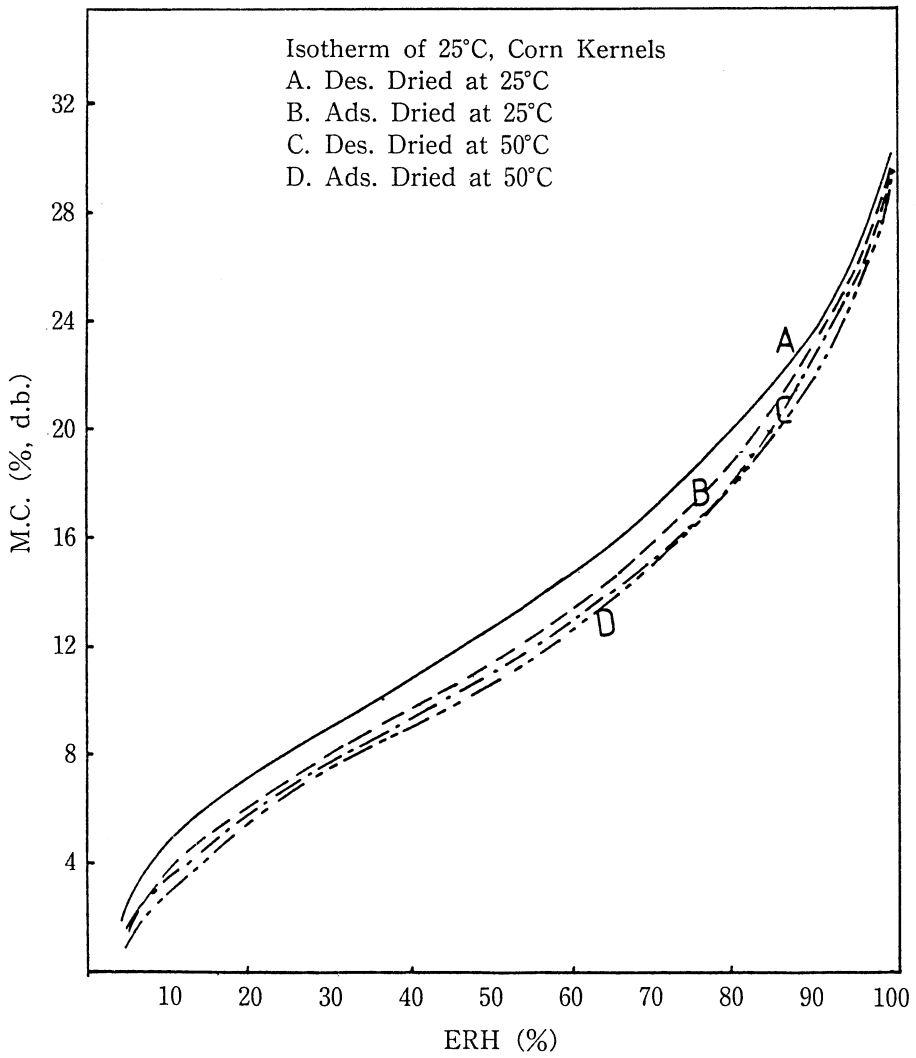


Fig. 5. The effect of drying temperatures on the isotherms of corn kernels.

Comparing of ERH values of this study with those obtained from the literature, the results are shown in Fig. 6. The sorption properties of corn kernels were affected by the cultivar, location, harvest years and other factors. More detail research need to be executed to define the factors.

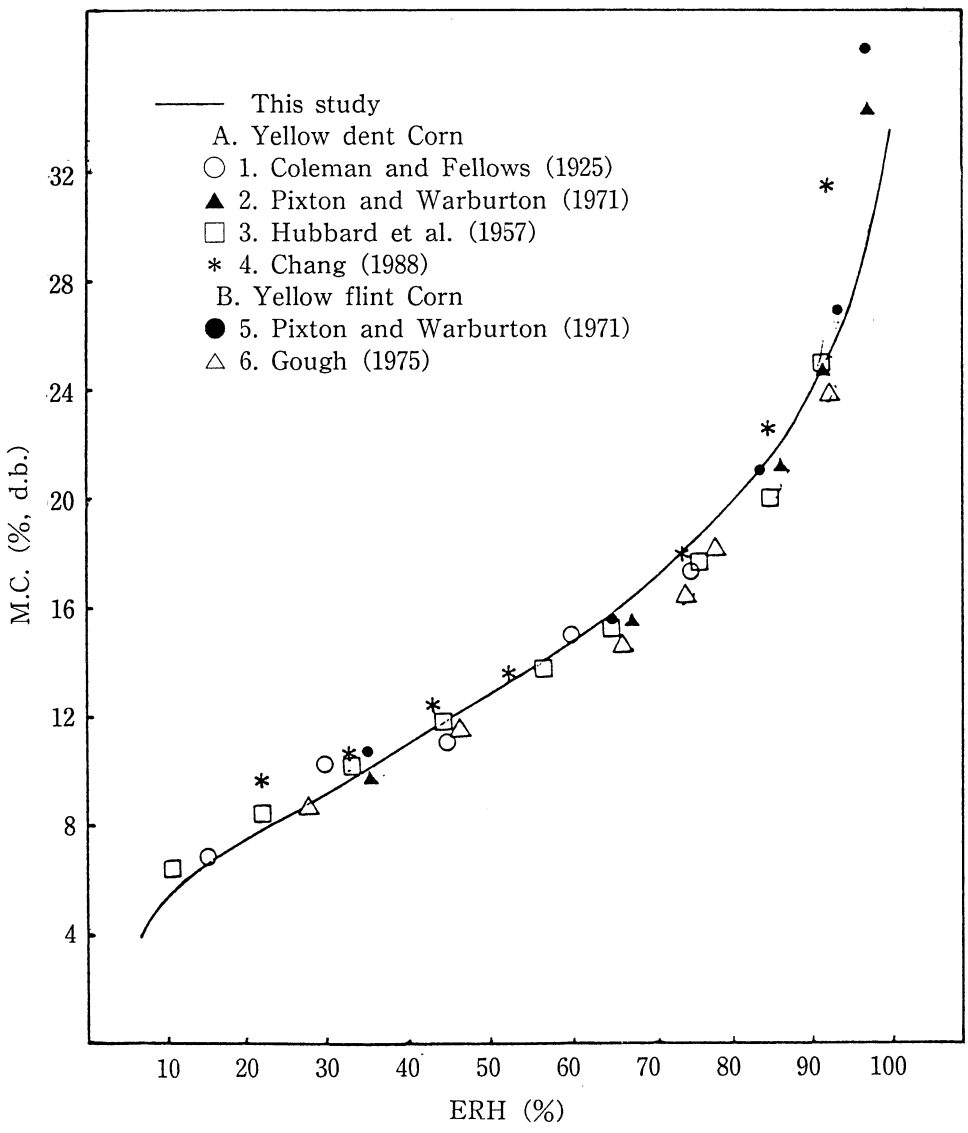


Fig. 6. Comparison of desorption isotherms of corn kernels with previously published data at 25° C.

Corn cobs

The effect of drying temperatures on the isotherms of corn cobs are shown in Fig. 7. At the same RH, the higher the drying temperature, the lower the moisture content and the less the effect of hysteresis. The effect of drying temperature on sorption isotherm of corncobs is more obvious than those of corn kernels and rice kernels.

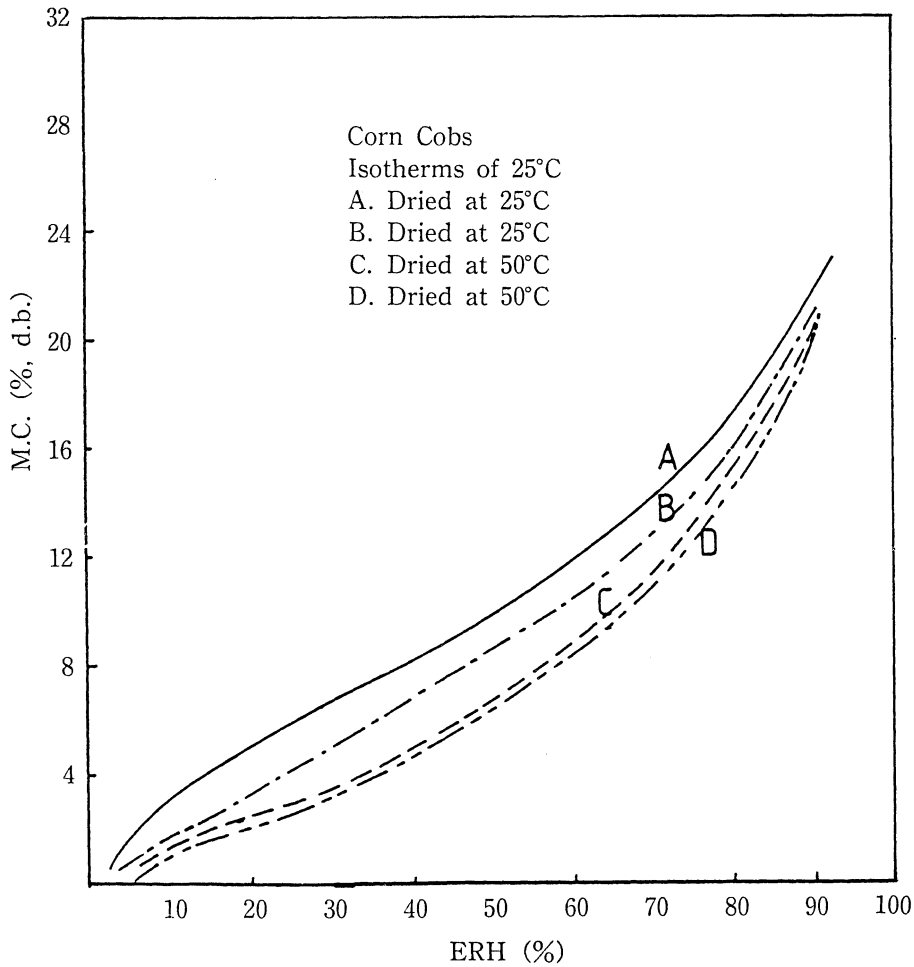


Fig. 7. The effect of drying temperatures on the isotherms of corn cob.

A comparison of desorption isotherms of 25°C in this study with those of White et al.[38] and Kumar et al.[20] is shown in Fig. 8. Above 50% RH, three curves are almost coincident at low RH range. The deviations were within 0.8% m. c. for three curves. There is a very good agreement among isotherms. It seems that variety and determinating method have little effect on the sorption properties of corn cobs.

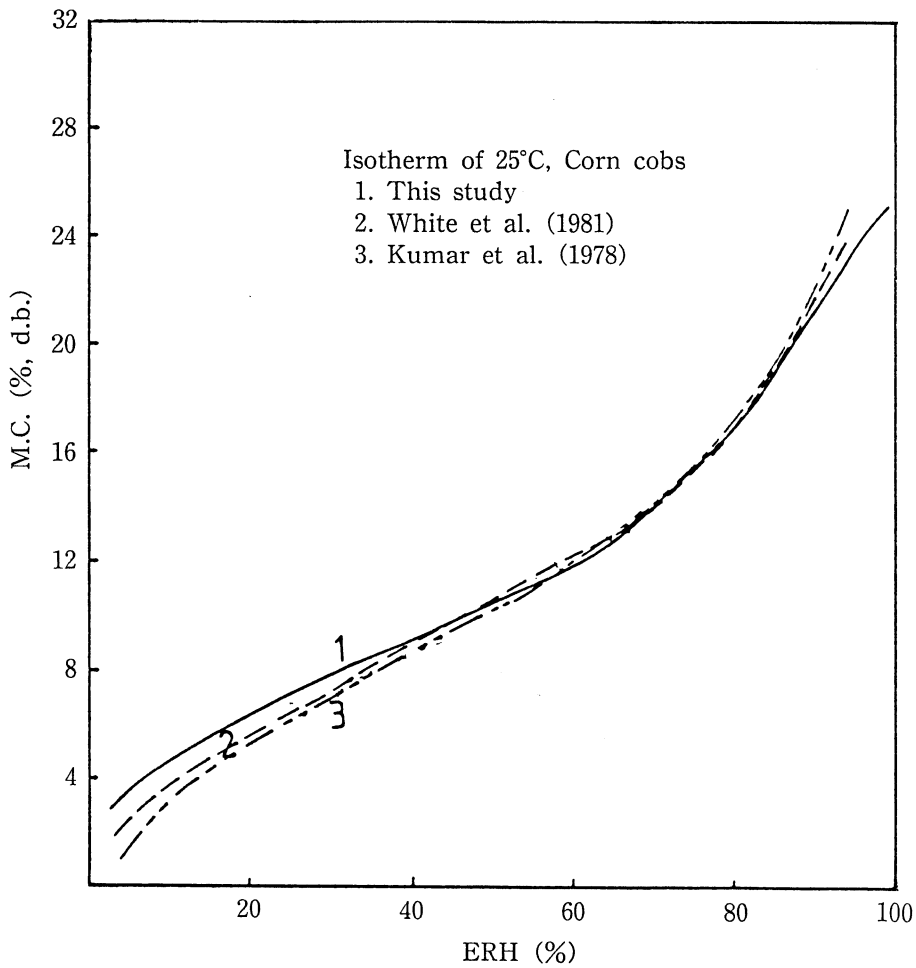


Fig. 8. Comparison of desorption isotherms of corn cobs with previously published data at 25° C.

Sorghum kernels

Comparing the isotherms at 25°C with data sets adopted from literature, the results are showed in Fig. 9 and 10. The wide distribution of the data scattering indicated the ERH /EMC properties of sorghum kernels were influenced by different factors.

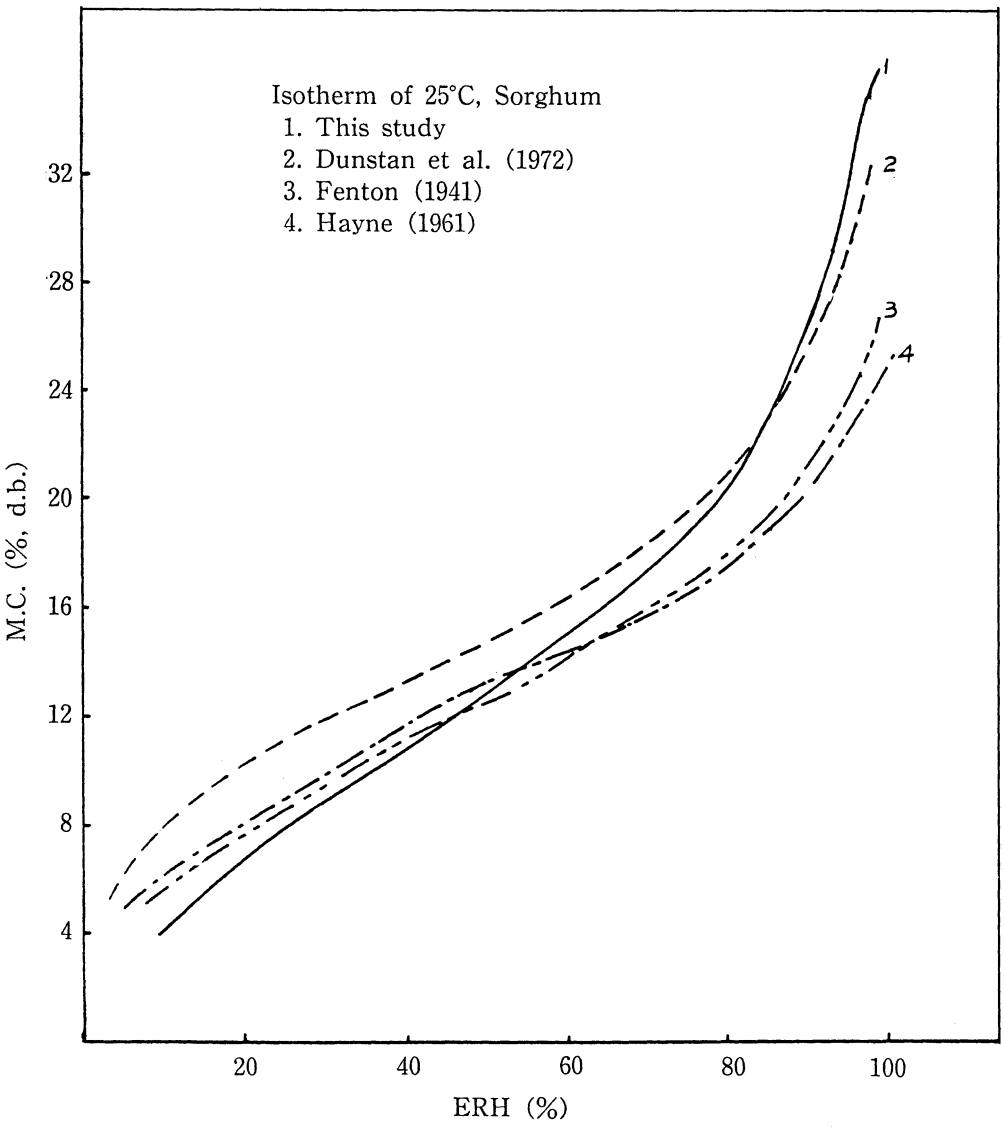


Fig. 9. Comparison of desorption isotherms of sorghum with previously published data at 25° C.

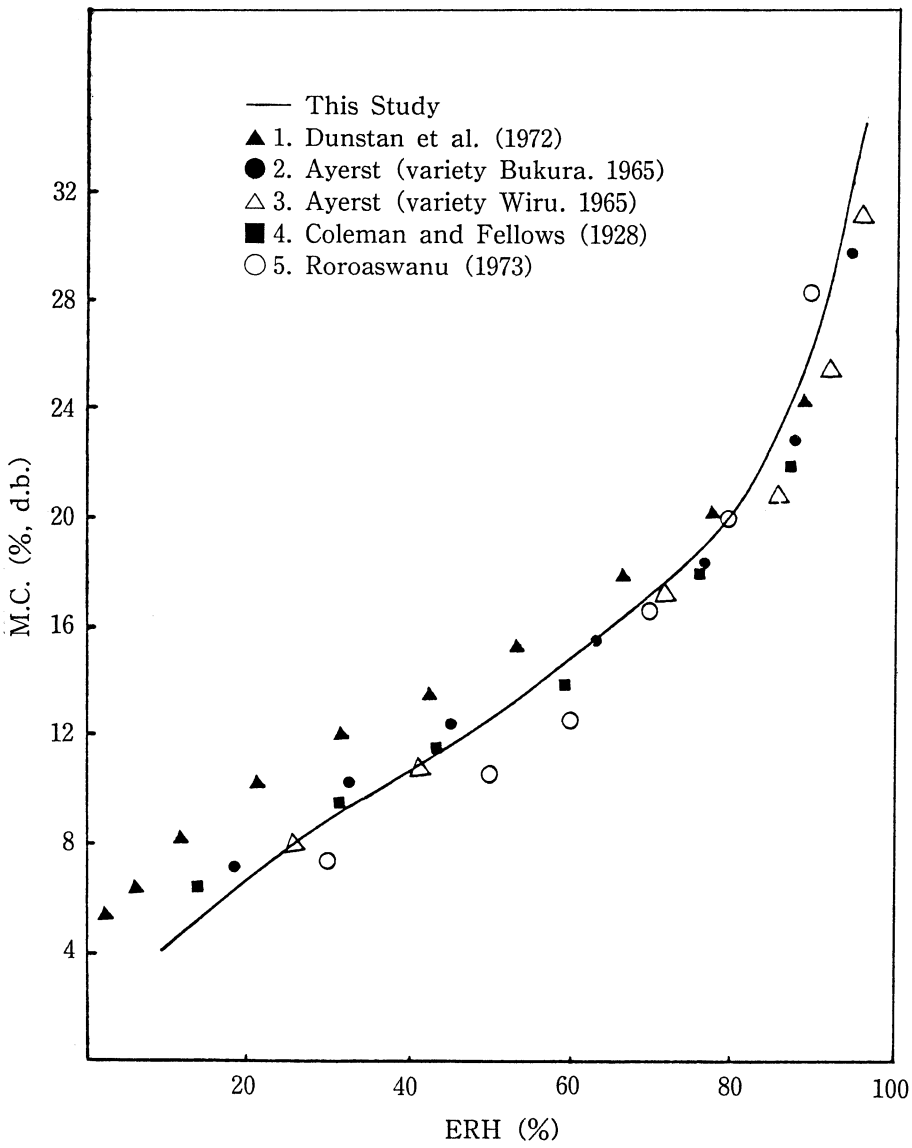


Fig. 10. Comparison of desorption data of sorghum with previously published data at 25° C.

Soybeans

There was no statistical significant difference between the desorption and adsorption data. Therefore, the two data sets were combined for further analysis.

The effect of drying temperatures is shown in Fig. 11. Little moisture hysteresis was found for sample dried at 25°C and no hystersis could be found for those dried at 50°C. The quantitative difference due to drying temperatures and hysteresis are insignificant for soybeans.

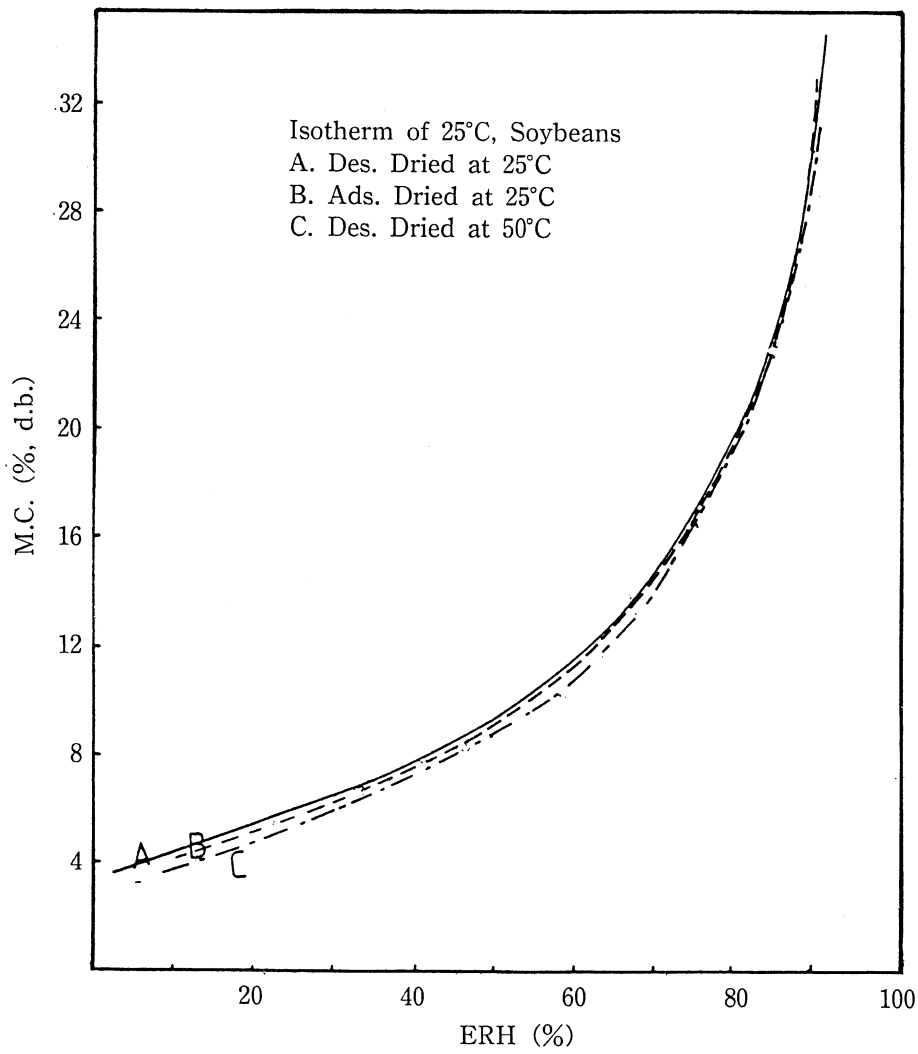


Fig. 11. The effect of drying temperatures on the isotherms of soybeans at 25° C.

The comparison of sorption data of this present study with previously published data are shown in Fig. 12. This comparison showed little difference among this study and five data sets except some data points above 80% RH, however, the obvious differences appeared among this study and seven data sets as shown in Fig. 13. The inconsistent results may indicated the unexplained experimental differences such as varieties, location and other factors.

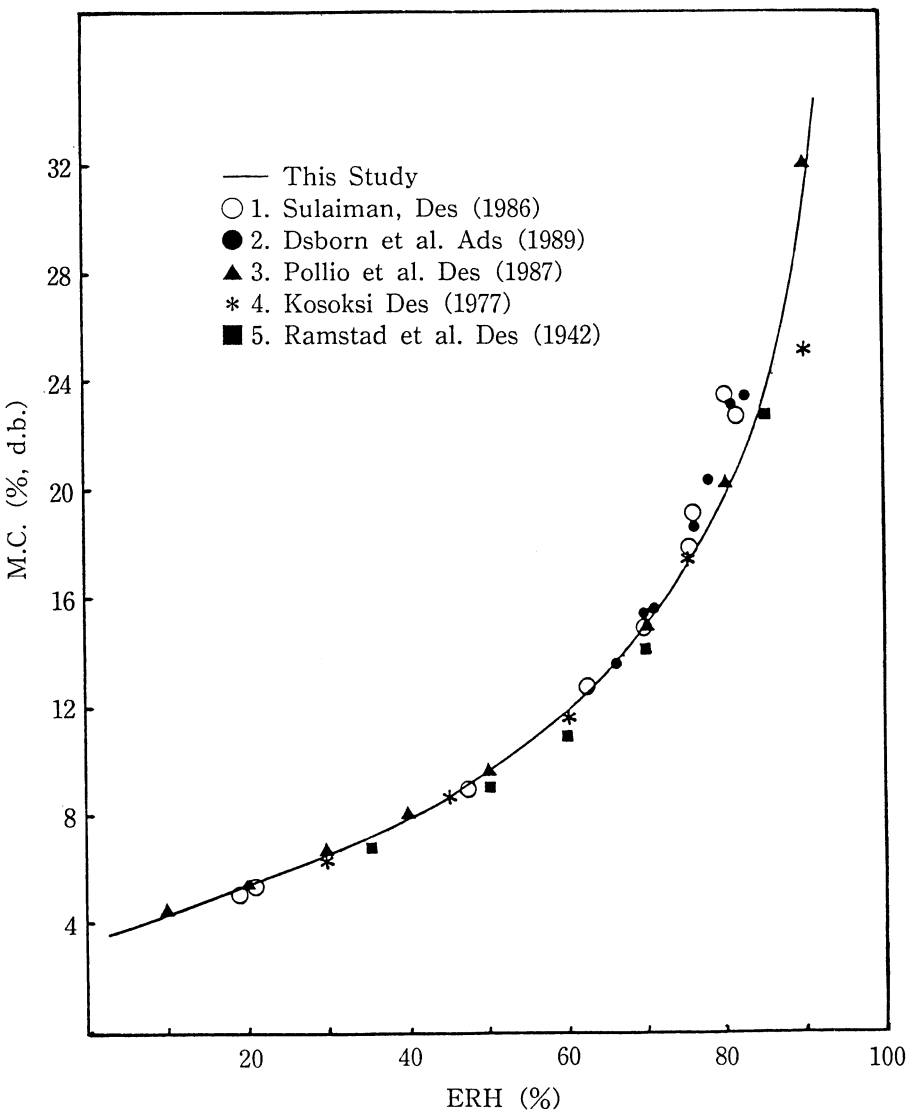


Fig. 12. Comparison of desorption isotherms of soybeans with previously published data at 25° C.

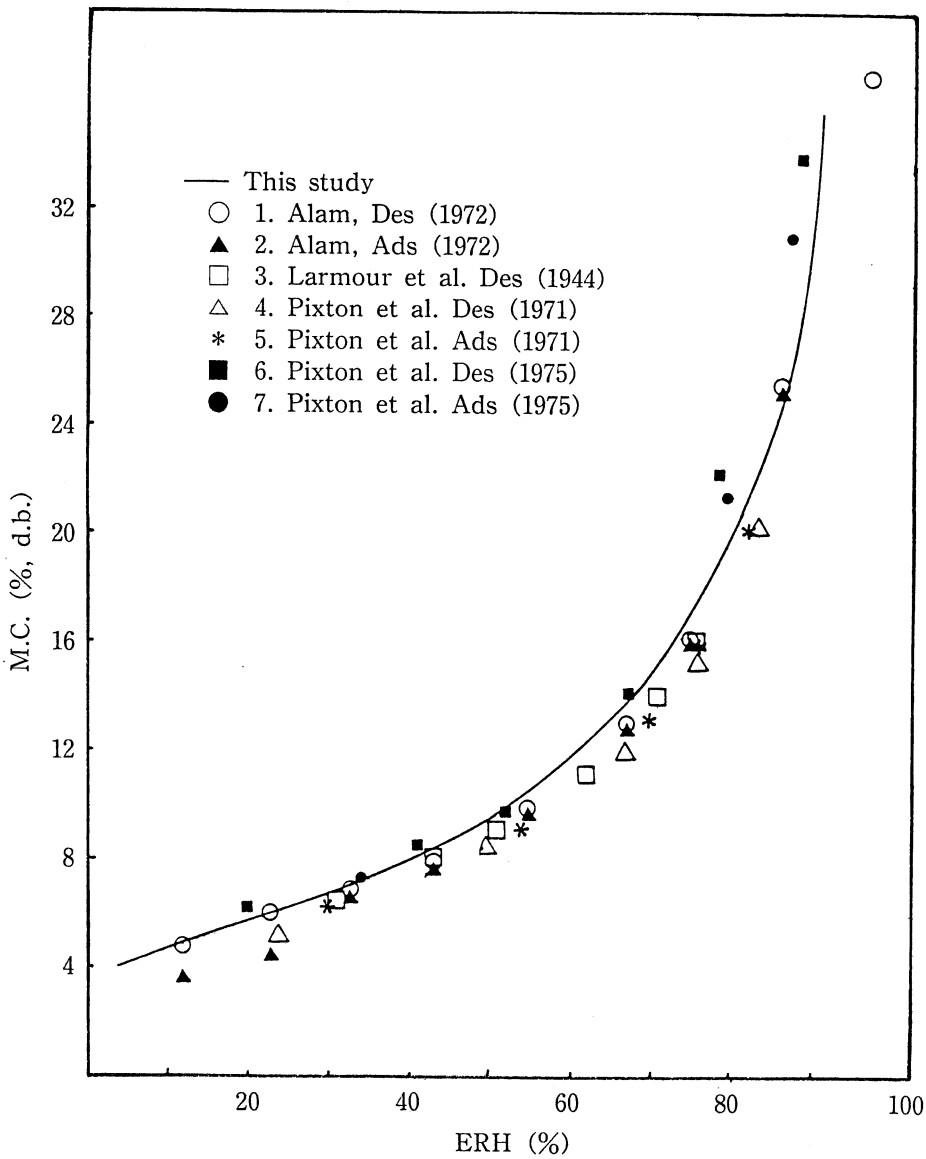


Fig. 13. Comparison of desorption isotherms of soybeans with previously published data at 25° C.

Red beans

There is no statistical difference between desorption and adsorption data for red beans dried at 50°C. The hysteresis of m. c. for red beans is within 0.6%. The hysteresis affected by drying temperatures is not important for this product.

The comparison of desorption data of this present study with three data sets is shown in Fig. 14. No significant difference could be found except two point data of Weston and Morris[39] above the 90% RH range.

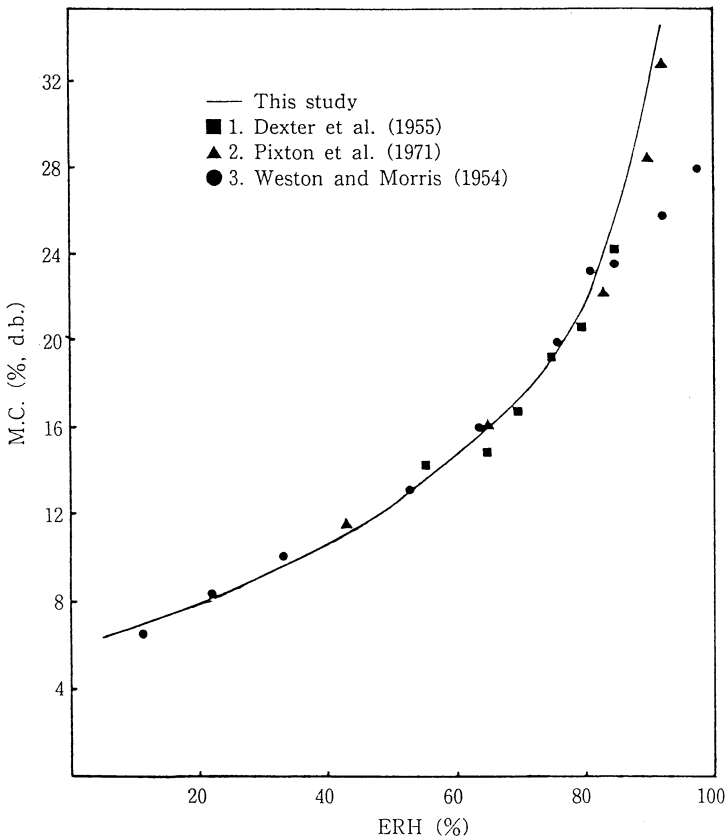


Fig. 14. Comparison of desorption isotherms of red beans

CONCLUSIONS

The ERH step-by -step determinating technique was performed to measure the desorption and asdorption properties of seven agricultral products dried with different temperatures.

The effect of drying temperature on ERH/EMC properties was significant for rough rice, corn kernels, and corn cobs, however, the effect of these properties is not obvious for soybeans and red beans.

The hysteresis of corn kernels was reduced by the drying temperatures, however, those of rough rice was not affected by drying treatments. Little moisture hysteresis was appeared in soybeans and red beans.

The results of comparison of this present study with previously published data are inconsistent for agricultural products. There is a good agreement among ERH/EMC data from different sources for the products of rough rice, brown rice, corn cobs and red beans. The inconsistent results were found for soybeans. The serious diversity of the scattering data

indicated those properties of corn kernels and sorghum kernels had been affected by the varieties, location and other factors. More detail experiments need to be executed to explain the inconsistent results.

ACKNOWLEDGEMENTS

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農產品平衡相對濕度影響因子研究[1]

陳 加 忠　　曹 之 祖[2]

摘　要

此研究中以 ERH 依序量測法量測七種農產品在 5 至50°C環境下之平衡相對濕度物性，用以比較此物性影響因子。研究結果顯示樣本之熱風乾燥溫度對稻穀，玉米粒與米梗之物性有顯著影響，但對大豆與紅豆之影響性不大。玉米粒的遲滯能力受乾燥熱風影響而降低，稻穀的遲滯性則不因熱風溫度高低而改變，大豆與紅豆之遲滯性十分小。以此研究結果與文獻之數據加以比較，各種農產品之結果並不一致。稻穀、糙米、玉米梗與紅豆與不同研究文獻數據之相互比較結果十分符合。大豆的物性則無一致性。玉米粒與高粱粒各研結果之數據顯著分散，顯示其影響因子十分複雜。

關鍵詞：平衡相對濕度。

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