

# RELATIONSHIP OF THE MOISTURE CONTENT OF FINNISH WHEAT FLOUR AND RELATIVE HUMIDITY

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It is generally known that flour moisture content varies with the relative humidity of air. The relative humidity at which a product, at a given temperature, neither gains nor loses moisture is called *equilibrium humidity*. If the equilibrium humidity is lower than the atmospheric relative humidity, the moisture content of the product tends to increase, and vice versa. Although the moisture relationships of different cereal grains are similar (COLEMAN and FELLOWS 1925), the adsorption and desorption isotherms of cereal flours are not the same. Thus different samples of same flour in equilibrium with the same atmospheric relative humidity may have a different moisture content (BABBIT 1949). The equilibrium moisture levels of flour are higher during desorption than during adsorption, a phenomenon called *hysteresis*. Therefore, the moisture loss during drying may be gained back only at a relative humidity higher than the original.

The relationship of the moisture content of wheat flour and relative humidity, as obtained by several workers (ANDERSSON 1937, ANKER *et al.* 1942, BAILEY 1920, FAIRBROTHER 1929), is summarized below:

Relative humidity %	Flour moisture — %				
	Bailey	Fairbrother	Anderson	Anker — <i>et al.</i>	
				25°C	37°C°
30	5.2	9.4		9.7	8.5
40	6.5	9.7		11.1	9.9
50	8.0	10.7	12.0	12.3	11.1
60	9.8	12.8	13.7	13.2	12.3
70	12.1	14.0	15.4	14.5	13.7
80	15.0	15.7		16.3	15.8
90		16.7			

It appears that the equilibrium humidity of flour of 14 % moisture is about 65 %, that of flour of 15 % moisture about 70 %, and that of flour of 16 % moisture about 75 %. The latter corresponds to that portion of the isotherm where relatively large quantities of «free» water are believed to become available to activate various grain enzymes and to be utilized by micro-organisms (LINKO 1960). Thus, in practice, cereal products in equilibrium with relative humidities of 75—80 % or higher may be expected to deteriorate rapidly at normal storage temperatures.

Although the relative humidity varies considerably in different parts of Finland, the monthly averages obtained from the measurements at various air port locations during ten years indicate relatively low monthly average humidities during the warm summer months:

	Relative humidity — %	
	Minimum	Maximum
January	87	92
February	84	89
March	77	84
April	71	79
May	64	71
June	64	70
July	70	76
August	77	82
September	81	86
October	86	90
November	89	93
December	88	93

During winter, the relative humidity in warehouses and storage rooms equipped with central heating may, for long periods, stay as low as 20—30 %. It may therefore be expected that flour of original moisture content of 15 % would tend to lose moisture during normal storage, and no special package appears necessary to prevent moisture migration. However, certain special cereal products, such as some types of prepared cake mixes, may have equilibrium humidity values as low as 30 % requiring a carefully chosen package to prevent a possible increase in moisture (BORCHARDT 1950). The purpose of the present study was to obtain information on the changes in moisture content of commercial Finnish wheat flour during storage at different relative humidities.

#### *Materials and methods*

A typical commercial Finnish wheat flour packed in standard 1000 g paper bags was chosen for the object of study, since the possible variations in flour moisture and net weight are greatest in a relatively small package. The average moisture content of flour at the time of packing was 15 %. Several samples of flour were stored in a warehouse at normal conditions, with a monthly check of the moisture content and a continuous recording of the relative humidity and temperature. Other samples were stored in air-tight glass chambers equipped with a fan and a hygrometer. The relative humidity was adjusted by means of water solutions of sulphuric acid. The

observed relative humidity ranges in various chambers were 32—34 %, 37—41 %, 44—46 %, 51—61 %, 63—68 %, 70—72 %, 80—87 % and 91 %. Some flour bags were occasionally transferred from one humidity chamber to another. The moisture content of flour was determined by drying for one hour at 130° C.

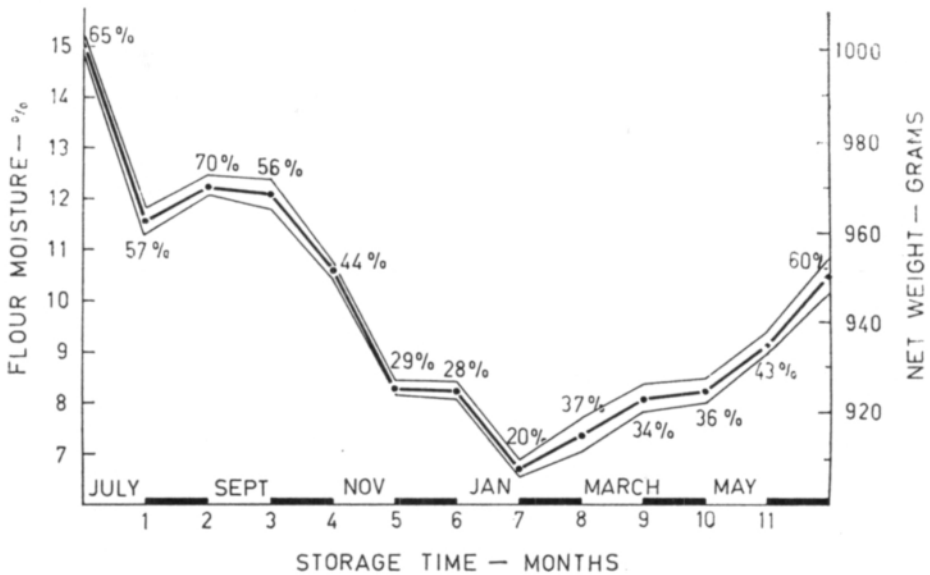


Figure 1. The variation of flour moisture content and net weight during warehouse storage for one year. The corresponding relative humidities are given on the graph. The area between the thin lines represents the magnitude of variation among the ten flour bags studied.

### Results and discussion

Figure 1. shows the average changes in moisture content of ten flour bags stored in the warehouse for one year, starting at the end of July. The relative humidity in the storage room decreased to a minimum of 20 % at the end of January. By that time the flour moisture content had dropped to 6.7 % from the original 15 %, representing a decrease of about 9.2 % in net weight. Thereafter the relative humidity increased gradually, approaching the starting value of 65 % at the end of July. During this time, the flour moisture content increased slowly to 10.5 %. After 12 months of storage, there had been a considerable total decrease in flour moisture, corresponding to a net weight decrease of about 50 g from the original 1000 g at 15 % moisture. These results clearly show that flour tends to dry considerably during normal storage conditions in Finland, the relative humidity in the warehouse rarely reaching the equilibrium humidity value of about 70 % for flour of 15 % moisture content. This is of importance since the quality of flour of low moisture content is affected little even during relatively long periods of storage.

Examples of changes in the flour moisture content during storage at variable relative humidities for a total period of two months are shown in Figure 2. The



normal storage in Finland, even if the relative humidity would exceed the critical level of 75—80 % for short periods.

### Summary

Changes in the moisture content of Finnish commercial wheat flour stored at variable relative humidities, representing the conditions typical of flour storage in Finland, were investigated. It could be shown that flour of 15 % moisture at the time of packing tends to dry considerably during normal storage conditions. Owing to the hysteresis effect, the moisture content of once dried flour is not likely to reach detrimental levels during normal storage, even if the relative humidity would exceed the critical level of 75—80 % for short periods. Minimum warehouse relative humidity was observed during January, at which time flour moisture had decreased to 6.7 %. The equilibrium humidity for flour of 15 % original moisture content was found to be about 70 %.

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### SELOSTUS:

#### ILMAN SUHTEELLISEN KOSTEUDEN VAIKUTUKSESTA KOTIMAISEN VEHNÄJAUHON KOSTEUSPITOISUUTEEN

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Kotimaisen vehnäjauhon kosteuspitoisuuden vaihteluita ilman suhteellisen kosteuden muuttuessa Suomelle tyypillisissä varasto-olosuhteissa on tutkittu. Tutkimuksissa voitiin osoittaa, että jauho, jonka kosteus pakkaushetkellä on noin 15 %, pyrkii kuivumaan huomattavasti normaalissa varastointiolosuhteissa. Hystereesi-ilmiöstä johtuen jauhon kosteuspitoisuus ei tyypillisissä varastointiolosuhteissa yleensä pääse kohoamaan haitallisen korkeaksi, vaikka ilman suhteellisen kosteus joksikin aikaa ylittäisikin kriittillisen rajan 75—80 %. Varastoilman alhaisin suhteellinen kosteus, 20 %, todettiin tammikuussa. Tällöin jauhon kosteuspitoisuus oli laskenut 6,7 %:iin. Jauhon, jonka kosteus pakkaushetkellä on noin 15 %, todettiin olevan tasapainotilassa noin 70 % suhteellisessa kosteudessa.