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THE RELATIONSHIP BETWEEN OUTSIDE AIR HUMIDITY AND FINISHED BISCUIT MOISTURE

SUMMARY

Data was collected by J. Menzies, the Quality Control Technician at Palmerston North Factory, to check out the possibility that Finished Biscuit Moisture is higher when the humidity of the air being drawn into the Weet-Bix ovens is higher. The following variables were measured - Moist Biscuit Weight, Flake Moisture, Oven Speed, Oven Temperature, Outside Air Humidity, Outside Air Temperature, and Finished Biscuit Moisture. The data was processed by computer using a Stepwise Linear Regression procedure, and it was found that humidity had no effect on Finished Biscuit Moisture. However, the data did show some significant correlations, some of which are already well documented, and these will be summarized below.

RESULTS AND DISCUSSION

Pairwise Correlations

The Stepwise Linear Regression program first prints out a correlation matrix which shows the relationship between all possible pairs of variables. There were 9 correlation coefficients greater than 0.321, which indicates a significance of better than 0.1%, which is the same as saying that such a correlation could arise purely by chance fewer than one time in a thousand. These correlations are summarized in Table I. A negative correlation coefficient indicates that as the independant variable increases, the dependant variable decreases.

Some of these correlations merely confirm common sense (3, 6, 7), verify a physical law (9) or add weight to work that I has already been done. (2).

However, there are some very good correlations that highlight effects that may not have been considered in the past to be important. For instance, Flake Moisture is well correlated with Oven Speed (4), having the highest pairwise correlation coefficient of all. The magnitude of the effect is not large,

the total range in Flake Moistures over all the data collected being only about 2%. However, Oven Speed does exert a very definite effect on Flake Moisture. This probably indicates that the drying effect as the flakes are conveyed from the mills to the ovens is related to Oven Speed. This is understandable, since a sustained increase in Oven Speed requires an increase in milling speed and this would result in a thicker layer of flakes on the conveyor and hence less drying.

Another important effect is the negative relationship between Flake Moisture and Oven Temperature. This would arise because of evaporative cooling. Higher Flake Moistures would have more cooling effect, and hence would produce a lower Oven Temperature in the absence of any corrective measures.

Actually the fact that the production line was under the control of an operator while this data was being collected will have obscured many relationships. For instance, from this data Flake Moisture has very little effect on Finished Biscuit Moisture, but this could be because the operator was taking steps to prevent Flake Moisture from adversely affecting Finishing Biscuit Moisture.

A relationship that is more difficult to explain is the way Flake Moisture varies with Air Temperature. If there was any effect at all, it would be expected to be a negative one, that is, higher Air Temperature produces lower Flake Moisture. However, in this set of data, the overall trend is in the opposite direction.

Effect of Air Temperature and Humidity on Finished Biscuit Moisture

The pairwise correlation coefficients were 0.141 and 0.154 respectively, which are not significant.

Stepwise Linear Regression

A Stepwise Linear Regression works by selecting the independant variable with the greatest effect on the dependant variable first. Other variables are added to the equation in order according to the extent by which they are able to improve the multiple correlation. The results are summarized in Table 2.

The independant variable with the greatest effect on Finished Biscuit Moisture is Moist Biscuit Weight, which is quite

understandable. On its own it accounts for 33.6% of the variation in Finished Biscuit Moisture. Oven Speed is the variable with the next greatest effect, explaining a further 9.6% of the variation in Finished Biscuit Moisture. Humidity is the third variable introduced into the equation, adding only 1.2% to the variation explained. With all variables included, only 45% of the variation in Finished Biscuit Moisture is explained.

CONCLUSION

Finished Biscuit Moisture does not show any correlation with Air Temperature or Relative Humidity. Even taking all variables into account this data explains less than half of the variation in Finished Biscuit Moisture. This implies either that there are other variables that have a large effect on Finished Biscuit Moisture, or that information has been obscured by the random data collection method. An experimental design could be found which would minimize the effect of random errors, but it would most likely be an unacceptable procedure since it would require the operation of the production line outside control limits.

The data does show that Finished Biscuit Moisture can be lowered to some extent by lower Moist Biscuit Weights, and Oven Speeds, and this is already well known. However, it may not be feasible to lower them any further because of their interaction with Packet Weight and production rate.

TABLE 1

SIGNIFICANT PAIRWISE CORRELATIONS

No.	Independant Variable	Related Dependant Variables	Correlation Coefficient
1	Moist Biscuit Weight	Oven Speed	0.356
2		Finished Biscuit Moisture	0.580
3	Flake Moisture	Moist Biscuit Weight	0.615
4		Oven Speed	0.655
5		Oven Temperature	-0.503
6		Finished Biscuit Moisture	0.523
7	Oven Speed	Finished Biscuit Moisture	0.496
8	Air Temperature	Flake Moisture	0.508
9		Relative Humidity	-0.436

TABLE 2

STEPWISE LINEAR REGRESSION SUMMARY

Step	Independant Variable Entered	Multiple R	% Variation Explained	Increase in Variation Explained
1	Moist Biscuit Weight	0.5799	33.63	33.63
2	Oven Speed	0.6574	43.22	9.59
3	Relative Humidity	0.6666	44.44	1.22
4	Flake Moisture	0.6678	44.59	0.15
5	Air Temperature	0.6703	44.93	0.33
6	Oven Temperature	0.6722	45.19	0.26