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PRODUCTION OF CELLULOSE FROM WASTE CONES OF THE *AGAVE TEQUILANA**

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PRODUCTION OF CELLULOSE FROM WASTE CONES OF THE <u>AGAVE TEQUILANA</u>

J. L. Herce Vigil*, J. F. Gómez**

ABSTRACT

This paper shows the experiments and conclusions obtained in the pulping process of leaves and cones of the maguey tequilero (Agave tequilana). These cones may be considered as an available important raw-material that till now has not been utilized for cellulose production. They represent the residuals of tequila production.

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AGAVE TEQUILANA FOR CELLULOSE PRODUCTION

INTRODUCTION

In recent years the lack of cellulosic material has been increasing and this has become a difficult problem for a country such as Mexico which has a weak economy and is trying to save foreign exchange by reducing imports. Due to the Mexican demand for cellulose which is growing at an annual rate of 10-15% and which the national production is not able to satisfy, imports of this commodity have been steadily increasing. (Mexico currently imports a third of its requirements of cellulosic materials while national production is only growing at a rate of 5.6% a year (1)).

A means towards easing this problem lies in research into other sources of raw materials for cellulose production. These could be industrial residues or raw materials that till now have not been used. The increasing scarcity of fibrous materials and the escalating prices of cellulose pulps (US$ 480-520/ton) (2) encourage the paper industry to study the processing of agricultural residues which works economically at low capacities. Before the present economic crisis these residues were not taken into consideration because their use was restricted by economic factors. It is well known that the minimum economic capacity for a cellulose plant is 100 tons/day. However, in Mexico there are several plants producing cellulose from cereal straws with capacities of 10, 12 and 80 tons/day, and most plants producing cellulose work below this minimum capacity (3).

Cereal straws and sugar cane bagasse, which is relatively abundant, have been employed as raw materials for cellulose production. Sugar cane bagasse now represents a partial solution to the problem, 25% of the cellulose consumed annually in Mexico is made from bagasse. In some Mexican research and development institutions, several other possibilities have been explored and according to the:

- quantity available, growth cycle and humidity contents;
- chemical analysis of the fibres;
- process and conditions of pulping;
- physical and mechanical characteristics of the pulp and legal aspects;

the "tequila" yielding "maguey" (Agave tequilana) was considered to be a promising raw material. The tequila yielding maguey is a plant with about 50 leaves ("pencas"). Sugars are extracted from the cone, the sugar liquor is then fermented and distilled to produce the well known Mexican tequila. Cones represent the residuals of the liquor production.

Waste material from the processed cones together with the leaves abandoned in the fields were used for cellulosic pulping in this study. The Agave tequilana is traditionally grown in the Mexican State of Jalisco. 21,000 hectares are presently cultivated and this area could be expanded to cover 65,000 hectares if the demand for tequila were increased. Approximately 55 million Agave tequilana aged from 2 months to 15 years are being tended (4,5).

PRELIMINARY STUDIES

According to the Wood Cellulose and Paper Institute of Guadalajara, Mexico (6), a fibrous material yield of 7.6% (dry basis) from the cones of Agave tequilana can be obtained while other sources (7) report that a yield of fibrous material of 5% (dry basis) can be obtained.

It has been shown (8,9) that it is possible to obtain 2.28 kg of fibre per cone and 2.0 kg of fibre per 50 leaves, therefore the fibrous material in a tequila yielding maguey is 4.28 kg. From the fibrous material it is possible to obtain 43% cellulose (4) i.e. 3.42 kg cellulose from 100 kg maguey. However, not all this cellulose could be obtained from the plant for two reasons:

Experiments in the laboratory showed that the use of leaves to produce cellulose is limited due to their high content of fines.

The leaves are left lying in the fields and their collection could be expensive.

Takig these arguments into account, conservative calculations can be made as follows: cone (85%) and leaves (15%) produce 2.86 kg of fibrous material, i.e. 1.15 kg of cellulose (43%) per maguey. According to the projected consumption of agave to 1987, the tequila production plants are processing 902 tons/day of maguey, that is a possible production of 20.7 tons of cellulose per day.

EXPERIMENT

The fibrous material was supplied by several distilleries from the Tequila Municipe of the State of Jalisco, Mexico. The "pencas" were cut into pieces of 3 or 4 cm width and processed through a Bauer mill. The fibrous material from both "pencas" and cones was dried, exposed to the air and mixed into a ratio of 85:15.

Chemical analysis was conducted according to TAPPI (Technical Association of the Pulp and Paper Industry). The results are shown in Table 1 which also includes the analysis of bagasse and soft wood by way of comparison. Table 2 shows the size of fibres, also in a comparative form. The Bauer Mc-Nett fibre classification is given in Table 3.

According to the chemical analysis data two types of variables were selected:

a) independent variables
- time
- temperature
- liquor percentage

b) dependent variables

- in pulp:
  - kappa number
  - yield
- in liquor:
  - pH
  - spent liquor

Table 4 shows the experimental conditions for the best runs. Pulping with soda was the process selected in accordance with the data reported in the literature. The pulps (runs No. 8, 9, 21 and 22) were selected to make paper, according to TAPPI standards ($69g/m^2$), and the physical/mechanical properties were evaluated. The results are given in figures 1-5.

RESULTS

The chemical analysis of bagasse and the cones from the Agave tequilana give similar results. However, the values of extracts, ash, and solubility in soda of the leaves ("Pencas") are higher than the values of bagasse. For this reason the mixture was prepared from 15% leaves and 85% cones. The soluble material found was quite high. This implies a higher reactive consumption, loss in yield due to solubility, partially cooked pulp, etc. Due to the nature of the fibres derived from the leaves, a reduction of the physico/mechanical properties was observed. Table 5 gives a comparison of the properties of paper made from bagasse and the best agave pulp.

The tear and fold factors could be considered as excellent when compared to the values obtained for sugar cane bagasse. The explosion factor and breaking length were found to be under the proposed values.

CONCLUSIONS

From this study it may be concluded that it would be possible to install a cellulose plant using cones of the Agave tequilana. An important aspect that must be underlined is the ease in collecting the bagasse cones from the tequila industrial centres located in the region of Tequila, State of

Jalisco. This means there is no collection problem as, for example, is the case with the Water hyacinth (*Eichhornia crassipes*). The bagasse cones can be sent directly to the cellulose unit. Impregnation effects could be considered in order to have a shorter cooking time and better yields. The leaves can be used only in a small proportion because their use results in a decrease of the physico/mechanical characteristics. Considering the value of the breaking length, it would be necessary to add 20-25% of conifer cellulose pulp to the pulp obtained from the *Agave tequilana* while it is in the mixing tank of the paper machine in order to obtain better paper characteristics.

REFERENCES

1. Cámara Nacional de las Industrias de la Celulosa y del Papel. Memoria Estadística, México (1985).

2. Paper Trade Journal. Vol. 170, No. 11, p. 8 (1986).

3. Cámara Nacional de las Industrias de la Celulosa y del Papel. Directorio de Socios, México (1982).

4. Promotora del Maguey. Inventario de Agaves, Mexico (1979).

5. Enríquez, R.A. Estudio de Prefactibilidad para Obtención de Pulpa Celulósica a Partir del Maguey Tequilero, Tesis, IPN (1981).

6. Instituto de Madera, Celulosa y Papel, Univ. de Guadalajara. Estudio del Maguey. Reporte de Laboratorio, México (1979).

7. Rosas, R., Castañares A., Consideraciones Técnico Económicas sobre el Empleo de Agavaceas en la Producción de Pulpa para Papel. Tecnología LANFI, Vol. 3, No. 3, p. 8-20, México (1976).

8. Gómez, J.F., Guerra, A., El Maguey Tequilero como Recurso Fibroso para la Obtención de Pulpa Celulósica. Revista de la Sociedad Química de México (in print) México (1987).

9. Mendiola y Macedo, S., Industry and Environment, UNEP, Vol. 6, No. 1, p. 23-25 (1983).

Table 1

CHEMICAL ANALYSIS OF FIBROUS RAW MATERIALS

Chemical Composition	Cane Bagasse (Sources)				Leave Bagasse (Penca)	Mixture	Sugar Cane Bagasse	Soft Wood
	Tototlan	Laja	Tequila	Sauza				
Cellulose %	47.80	41.13	44.31	46.75	42.18	43	47.0	51.0
Lignin %	23.24	21.75	19.63	20.58	13.99	20	18.0	28.0
Extracts %	13.99	7.06	9.39	11.31	25.96	13	7.0	5.0
Hemicellulose %	14.91	30.05	26.05	21.35	17.86	20	28.0	18.0
Ash %	3.06	2.35	3.42	3.36	11.37	4	1.6	0.4
Solubility % (NaOH 1 %)	32.56	24.61	31.31	22.85	55.75	32.0	30.0	18.0

Table 2

Dimensions of fibres

	Agave tequilana			
Dimensions in mm	Leaves	Cones	Connifer wood	sugar-cane bagasse
Lenght	1.46	1.71	3.50	1.8
Diameter	0.031	0.022	0.035	0.018
L/D	47.5	77.7	100	100

TABLE 3

BAUER-McNETT CLASSIFICATION OF FIBRES (MIXTURE)

	RETENTION %
MESH No. 10	52.84
MESH No. 14	5.49
MESH No. 28	4.37
MESH No. 200	10.26
SOLUBLES	27.04

CONDITIONS

580 rpm

20 min

10 g of dry fiber

TABLE 4

COOKING CONDITION		8
TEMPERATURE	°C	160
TIME	min	40
COOK LIQUOR IN MIXTURE	%	10
LIQUOR TO MIXTURE RATIO	-	4:1
CONSISTENCY	%	26.2
COOKING RESULTS		
YIELD	%	56.85
KAPPA NUMBER		106
C.S. FREENESS	ml	336
SPENT LIQUOR	%	0.44
INITIAL pH	-	13.0
FINAL pH	-	8.4

EXPERIMENTAL RESULTS

RUN No.

9	21	22
170	170	160
50	20	20
15	10	10
4:1	4:1	4:1
31.1	28.75	27.35
59.80	63.36	70.75
104	108	109
464	408	431
6.02	1.77	1.27
13.0	13.3	13.3
10.4	9.5	9.2

TABLE 5

PHYSICO-MECHANICAL PROPERTIES

	SUGAR CANE BAGASSE (FREENESS 300-400 ml)
BURST FACTOR	20 min
BREAKING LENGTH	4000 min
TEAR FACTOR	30 min
FOLDING RESISTANCE	50 min

AGAVE (RUN 9)
(FREENESS 300 ml)

136
3300
64
132

FIGURE 1

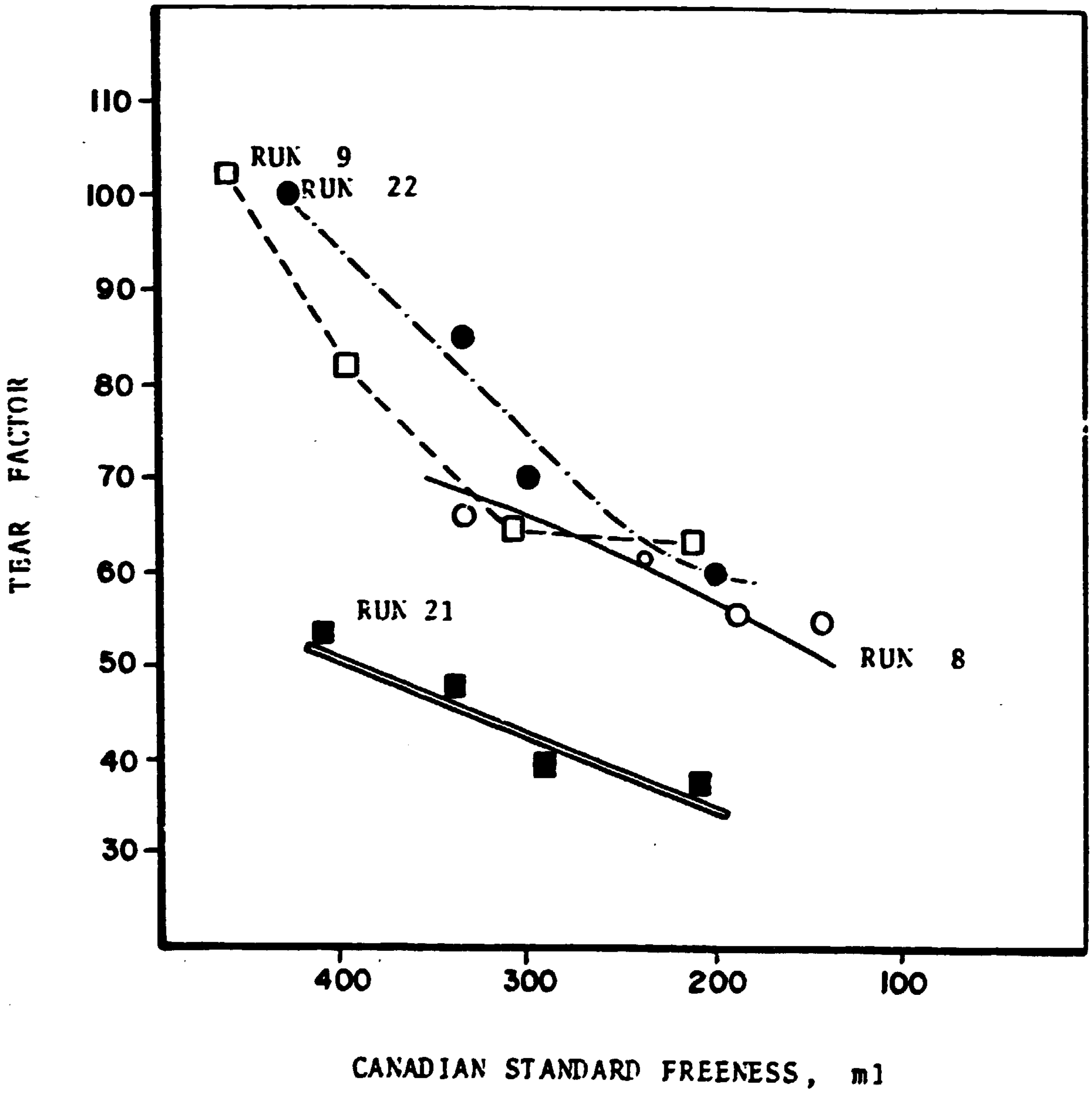

RUN 9
RUN 22
RUN 21
RUN 8
110
100
90
80
70
60
50
40
30
TEAR FACTOR
400
300
200
100
CANADIAN STANDARD FREENESS, ml

FIGURE 2

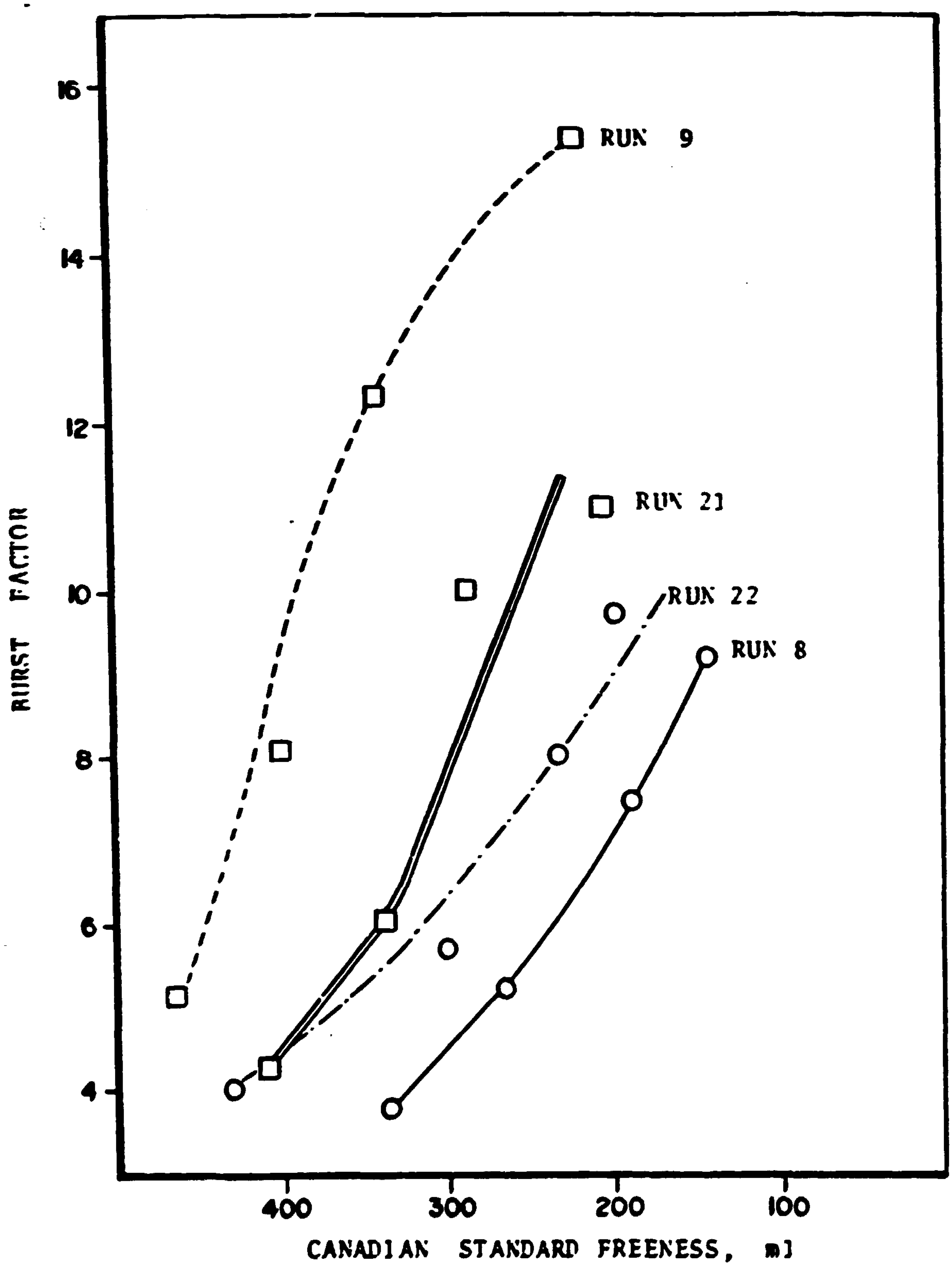

RUN 9
RUN 21
RUN 22
RUN 8
BURST FACTOR
16
14
12
10
8
6
4
400
300
200
100
CANADIAN STANDARD FREENESS, ml

FIGURE 3

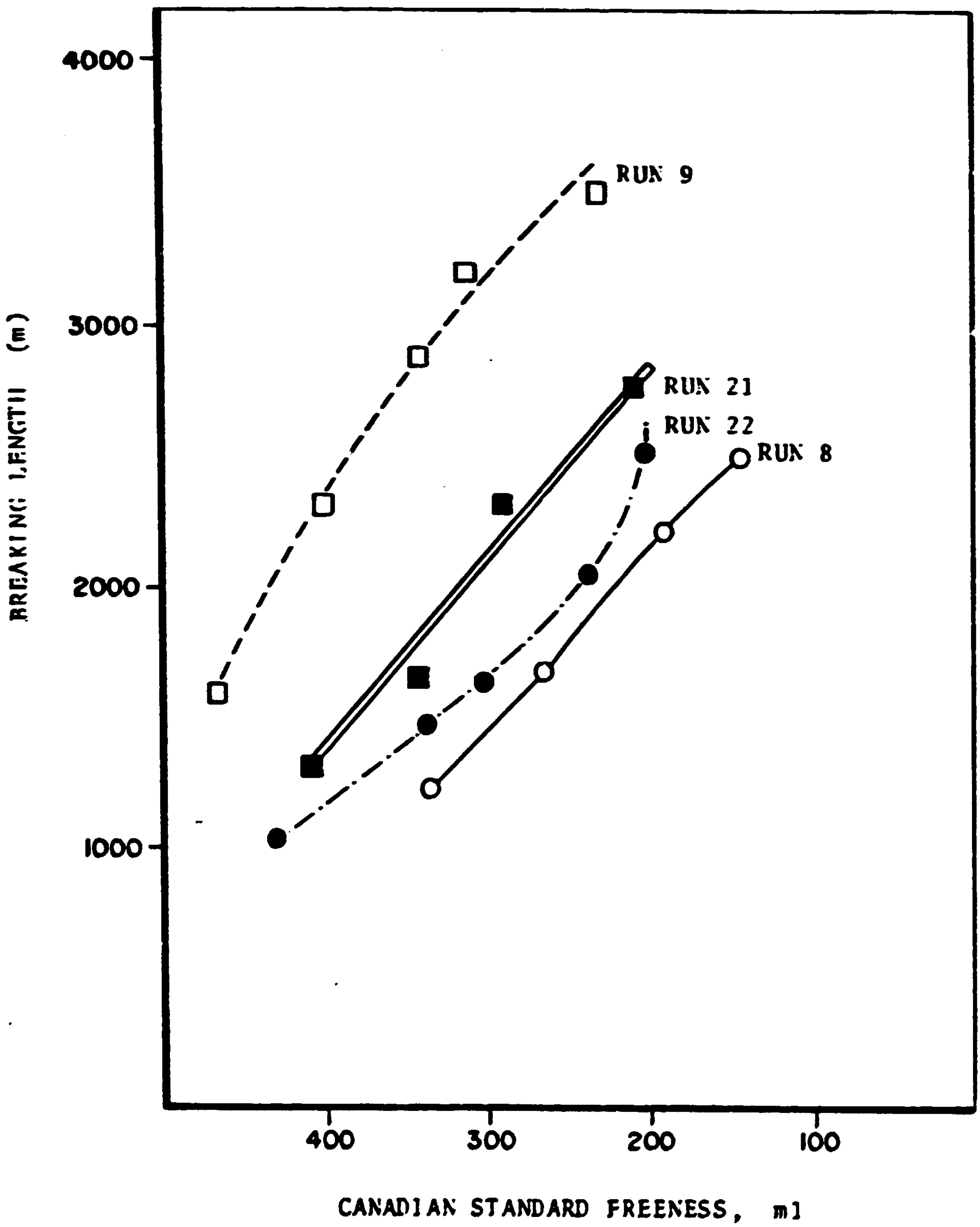

4000
3000
2000
1000
BREAKING LENGTH (m)
RUN 9
RUN 21
RUN 22
RUN 8
400
300
200
100
CANADIAN STANDARD FREENESS, ml

FIGURE 4

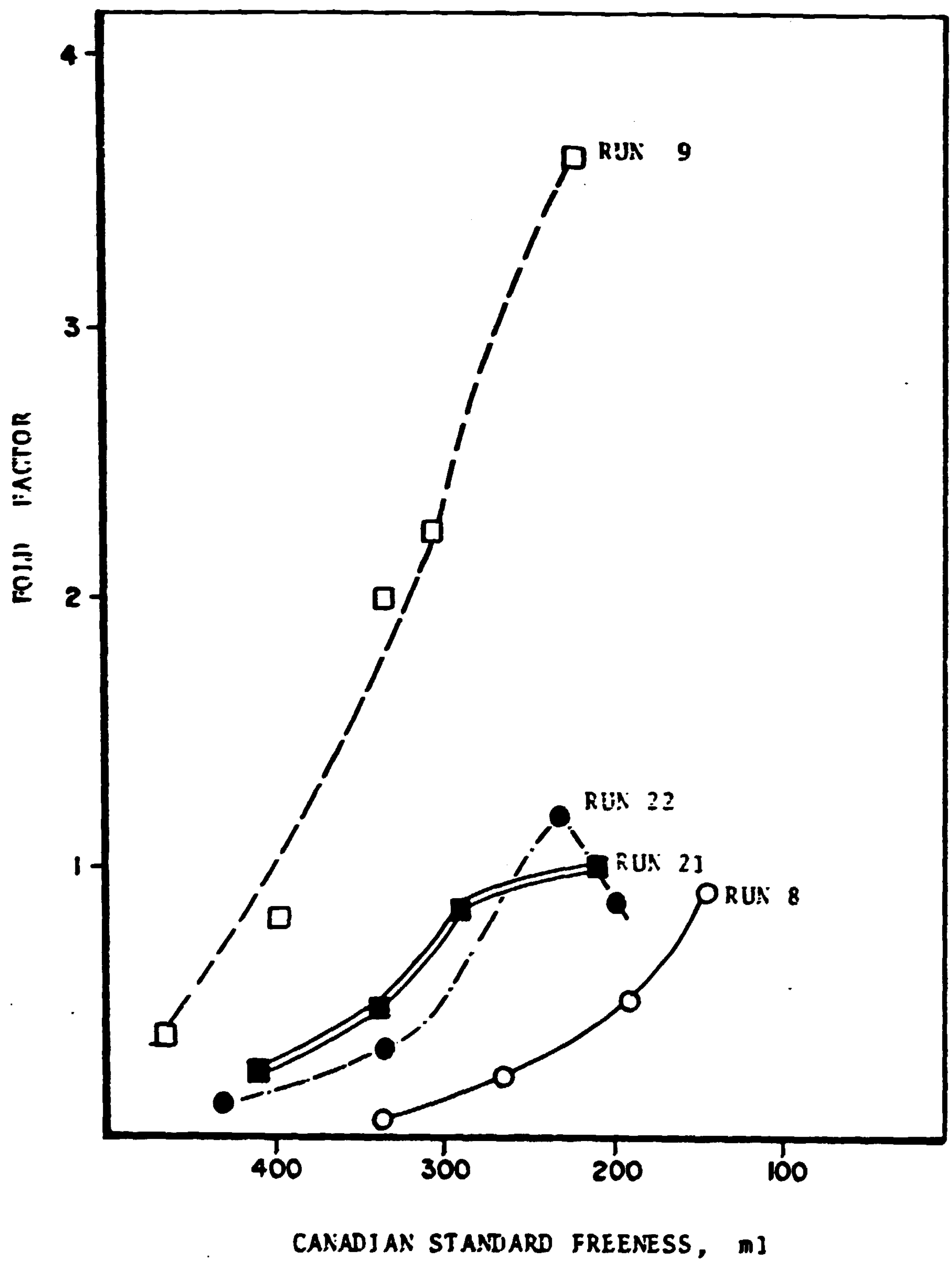
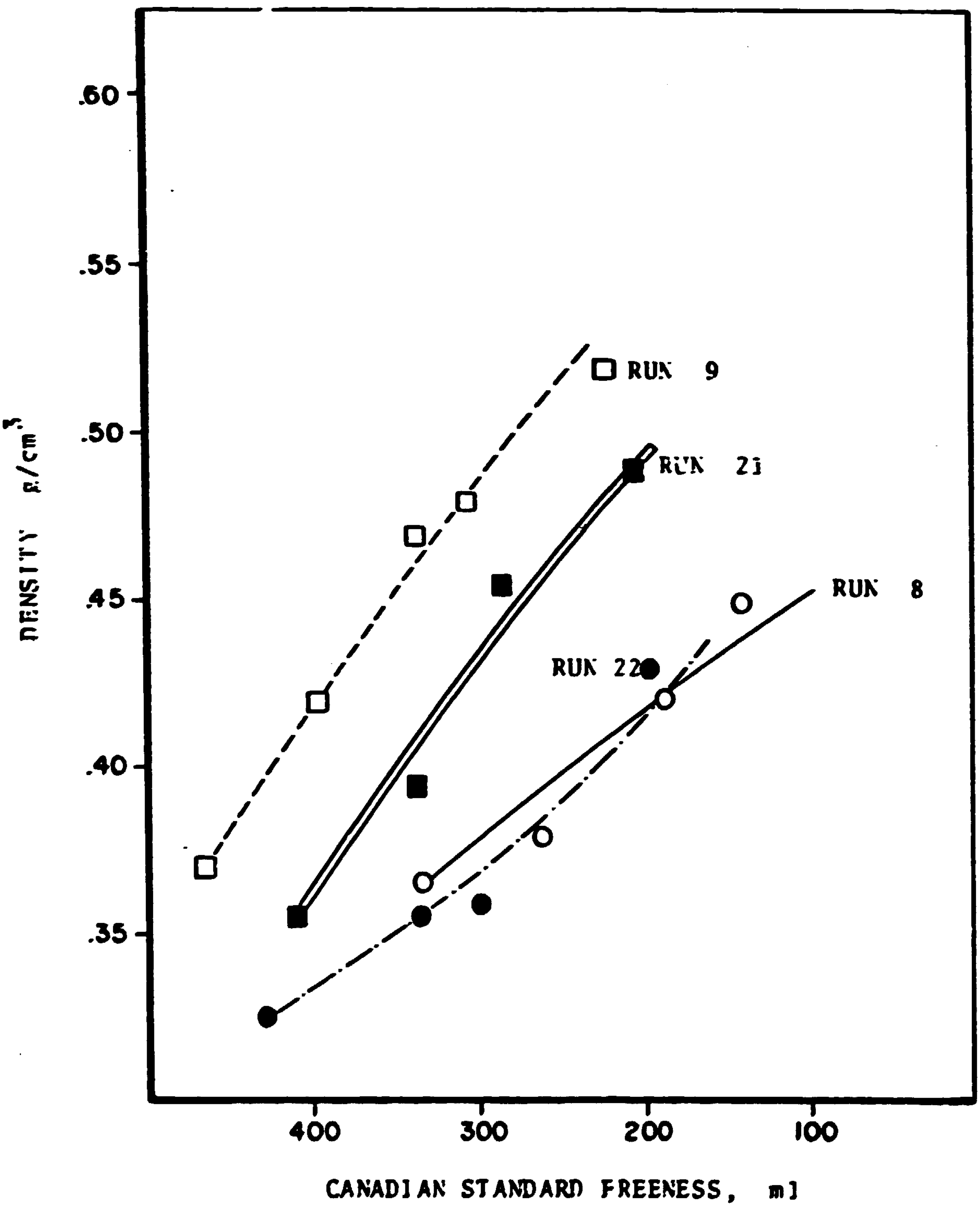

RUN 9
RUN 22
RUN 21
RUN 8
4
3
2
1
FOLD FACTOR
400
300
200
100
CANADIAN STANDARD FREENESS, ml

FIGURE 5


.60
.55
.50
.45
.40
.35
DENSITY g/cm³
RUN 9
RUN 21
RUN 8
RUN 22
400
300
200
100
CANADIAN STANDARD FREENESS, ml