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GINGER PROCESSING INVESTIGATIONS. 2. AN IMPROVED METHOD FOR THE SUGAR IMPREGNATION OF GINGER BY CONTINUOUS EVAPORATION

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SUMMARY

Equipment and techniques were developed to avoid sudden changes in Brix and low yields. A continuous automatic evaporative syruper when operated at low temperatures increased yields, improved colour and reduced labour costs.

I. INTRODUCTION

By December 1955, the ginger industry in Queensland had reached a stage where the quality approximated that of the imported product as a result of rigid control over harvesting time and more efficient processing techniques (Leverington 1969*b*), but one major problem had to be overcome, viz. the establishment of a consistently high-yielding process.

Fundamentally, the sugar impregnation process is the migration of sugar molecules in solution from a syrup containing a high concentration to the ginger of lower concentration under the influence of osmotic pressure. Graphically, the changes in Brix of the syrup and ginger can be represented as shown in Figure 1, assuming that approximately equal weights of ginger and syrup are used at the commencement of the process. This ratio had been found the most economical from the point of view of plant capacity while giving sufficient fluidity to the mixture to enable it to be easily agitated manually.

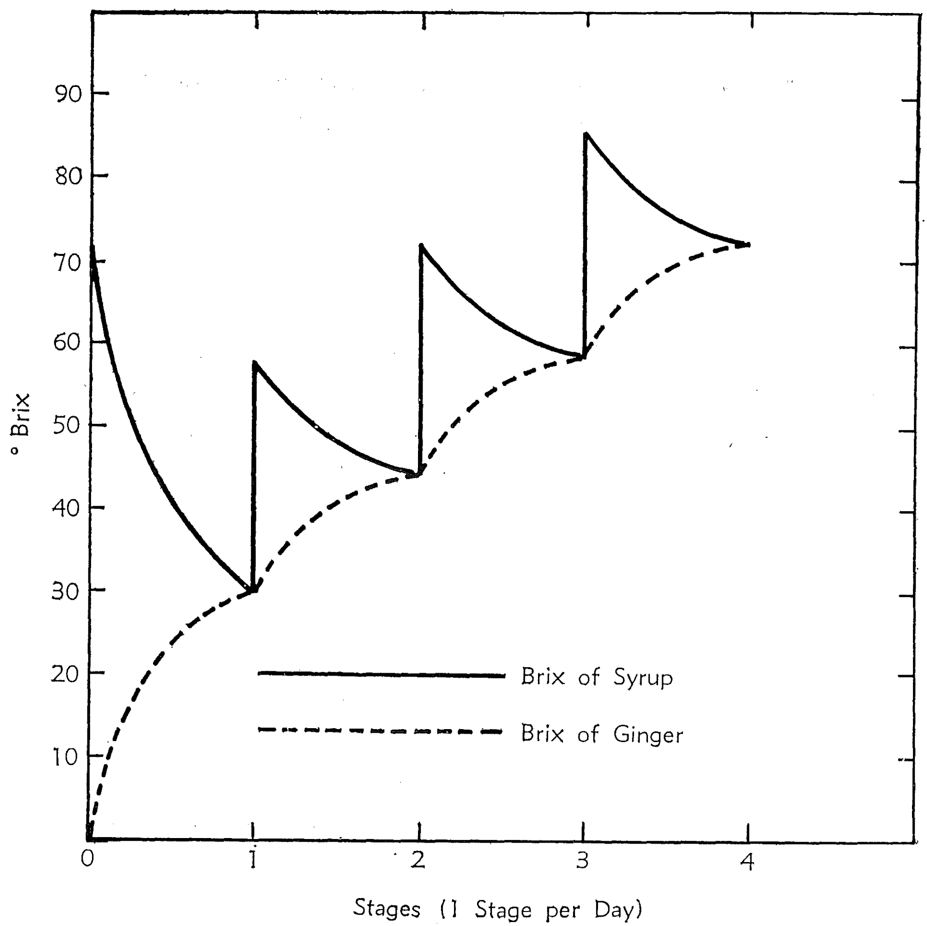

Fig. 1.—Brix changes in syrup and ginger during 4-stage chain batch process.

It can be seen that there will be major osmotic pressure differences as the fortified syrup is returned to the ginger, and it has been observed that the greatest shrinkage of the ginger occurs at this stage. As the sugar concentrations in the two phases approach one another, the osmotic pressure difference becomes less, and less shrinkage occurs. By extending the process over 9 days instead of four, the maximum osmotic pressure differences are correspondingly less, less shrinkage occurs, and hence higher recoveries should be obtained. This procedure is represented diagrammatically in Figure 2.

It was postulated that if the osmotic pressure difference could be kept small and constant, a higher recovery should be possible. This proposed process is shown graphically in Figure 3.

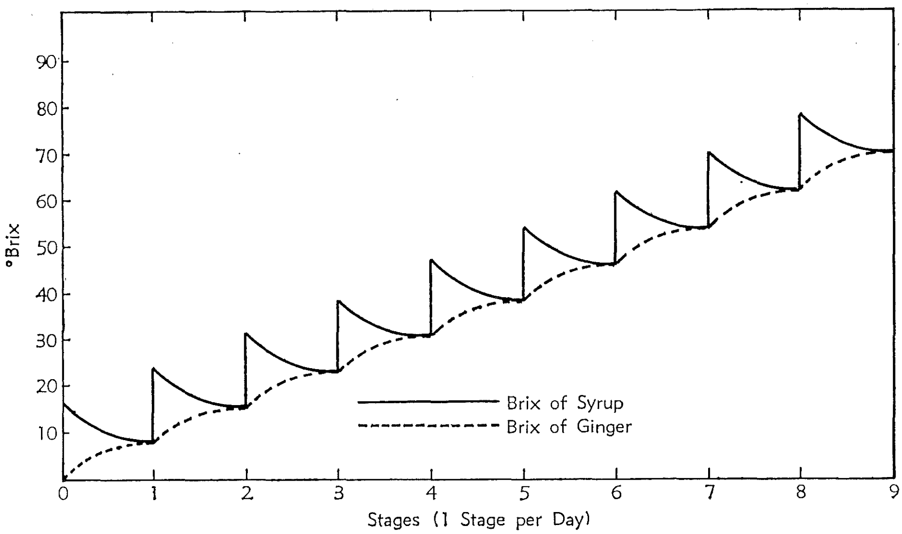

Fig. 2.—Brix changes in syrup and ginger during 9-stage chain batch process.

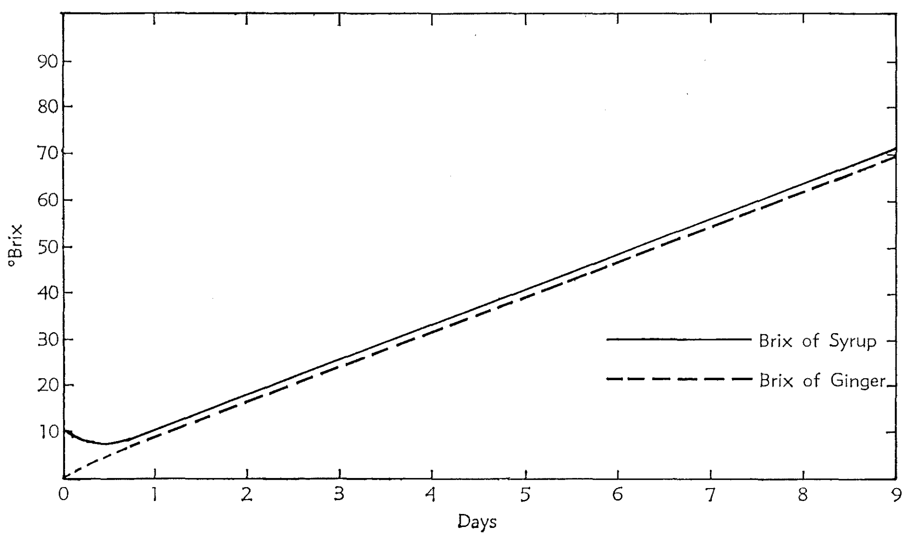

Fig. 3.—Brix changes in syrup and ginger during continuous evaporation process.

Attempts were made to prove this theory by continuously evaporating syrup containing diced ginger, by heating in a beaker on a warm hotplate. This procedure proved unsatisfactory owing to the lack of agitation and the tremendous bulk of starting syrup required to ensure that the ginger was just covered when the equilibrium Brix of 72 was reached. This method was discarded and a continuous automatic evaporative syruper designed and set up as shown in Figure 4.

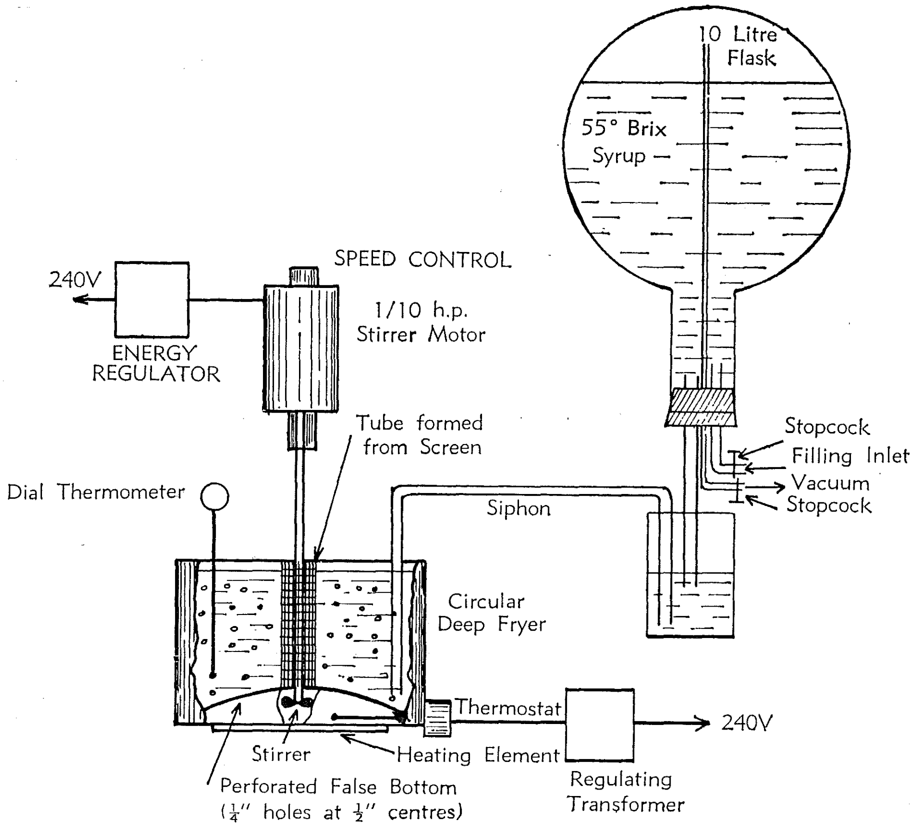

Fig. 4.—Continuous automatic evaporative syruper.

II. DESCRIPTION OF EQUIPMENT

The evaporation vessel consisted of a domestic circular 1,500W deep fryer fitted with a thermostat. The current was reduced to avoid violent fluctuations in temperature by reducing the voltage input to approximately 80 by means of a regulating transformer. To maintain a constant temperature in the vessel, a stirrer driven by a $\frac{1}{10}$ h.p. motor was fitted beneath a perforated aluminium screen which formed a false bottom in the deep fryer. This formed a space in which the propellor could agitate the syrup without fouling the pieces of ginger. It was run intermittently to avoid unnecessary power consumption. A $\frac{1}{4}$ in. mesh stainless-steel tubular wire screen about $1\frac{1}{4}$ in. in diameter was fitted around the shaft to keep the ginger clear and also to permit a vortex to be formed down the centre of the vessel to ensure efficient agitation. A temperature of approximately 110°F was maintained in the vessel. As evaporation of water lowered the level of liquid, 65 Brix syrup adjusted to the desired reducing sugar level was fed into the evaporator vessel from the inverted 10 l. flask by means of the intermediate vessel and siphon. Some irregularities in liquid level in the evaporator vessel occurred during the early stages of the process due to the difference in specific gravity of the two syrups. This was overcome by carefully adjusting the level of the lower end of the flask discharge pipe, and by increasing the diameter of syrup-carrying pipes to ½ in.

III. DESCRIPTION OF PROCESS

The ginger used in these experiments was grown under irrigation at the Maroochy Experiment Station and after grading was brined in a solution of sulphur dioxide before processing. Then 1,500 g of choice stringless ginger were boiled for ½ hr in water containing 7·5 g citric acid, and overflow rinsed vigorously for 2 min with water at 190°F. It was brought to the boil again, boiled for ½ hr, overflow rinsed again, then boiled again for ½ hr, making 1½ hr boiling altogether. (More recent experience has shown that the time of cooking depends upon the quality of the raw material and that the procedure must be adjusted accordingly). After cooking, the ginger was finally overflow-rinsed with cold water, drained, placed in the deep fryer, and covered immediately with 2,500 g 10 Brix sucrose syrup which was at room temperature. About 7,000 g 65 Brix syrup suitably inverted were fed into the 10 l. flask by suction and then the siphon system was connected. The heater was turned on, the agitator started at a rate of about 300 r.p.m., and the temperature adjusted to the desired level. As the viscosity of the syrup increased it was necessary to increase gradually the speed of the stirrer to about 800 r.p.m. by the time a Brix of 60 had been reached. Evaporation was continued until the Brix of the syrup had reached 70–74. The ginger was allowed to stand in the syrup for several days to reach equilibrium.

IV. DISCUSSION

Table 1 (Short Continuous Process) shows that the time required for samples of stringless and fibrous ginger to reach an equilibrium Brix of appproximately 72 when processing at about 120°F averaged 4 days. The yield of stringless ginger was very variable but in each individual batch the percentage gain in fibrous ginger was very much greater than in the choice ginger.

Table 2 shows the time required for samples of stringless ginger to reach equilibrium Brix of approximately 72 when processing at 110°F. The average processing time was 9·7 days. The yields were not so variable as those in Table 1 and always showed a gain. It appears that the longer brining of E, F, G and H as compared with B, C and D may have had some bearing on the higher yields. If this is so, then brining periods longer than 1 month would seem to be necessary to obtain a reasonable yield if a short process is required.

TABLE 1

Brix Changes with Time of Processing and Yield of Product

Sample No.	A		B		C		D	
Storage time in brine (months) ..	1		1		1		1	
Approximate ratio of stringless to stringy ginger used in batch	All stringy		5½ : 1		5 : 1		5 : 1	
	Hours	Brix	Hours	Brix	Hours	Brix	Hours	Brix
	0	10·0	0	10·0	0	10·0	0	10·0
	49·5	30·0	17·0	24·0	25·0	35·2	43·0	55·7
	67·0	48·0	19·5	24·5	47·5	53·1	46·0	60·4
	72·5	52·0	22·0	25·5	83·5	64·9	48·5	61·0
	73·5	53·5	24·5	26·8	108·5	71·0	70·0	70·0
	87·0	64·5	29·0	38·4	112·5	74·0	92·0	73·6
	92·5	67·0	34·5	49·0	..	..	..	..
	95·0	67·5	36·0	51·3	..	..	..	..
	111·0	73·0	56·0	63·9	..	..	..	..
	..	..	61·0	66·7	..	..	..	..
	..	..	77·0	70·9	..	..	..	..
	..	..	80·0	74·3	..	..	..	..
Approximate processing time (days) ..	4½		3½		4⅔		4	
Average loss or gain in drained weight after processing (%)	15·3 gain		19·0 gain		4 loss		2·2 loss	
Loss or gain in drained weight of stringless ginger (%)	—		10·2 gain		4·4 loss		24·0 loss	
Loss or gain in drained weight of stringy ginger (%)	15·3 gain		35 gain		0·18 gain		12·0 gain	

TABLE 2

Brix Changes with Time of Processing and Yields of Product
Stringless ginger brined for 3 months

Sample No.	E		F		G		H	
	Hours	Brix	Hours	Brix	Hours	Brix	Hours	Brix
	0	10·0	0	10·0	0	10·0	0	10·0
	27	21·6	96	51·4	72	41·3	95	39·3
	99	51·2	115	54·6	116	58·8	160	60·6
	110	58·4	139	59·0	245	67·5	209	66·4
	158	65·5	165	62·3	269	70·0	240	71·0
	186	70·4	236	70·3	..	..	..	..
Approximate processing time (days)	8	..	10	..	11	..	10	..
Gain in drained weight after processing (%)	16·6	..	8·3	..	17·0	..	19·0	..

Table 3 shows the percentage gain in yield when stringless ginger was processed in 8–13 days. Samples J, K, L, M, N and O had all been brined for about 8 months and a consistently high yield was obtained. In sample P, which was freshly harvested and processed without brining, the loss in yield was 14%.

TABLE 3

GAIN OR LOSS IN DRAINED WEIGHT AFTER PROCESSING
Stringless ginger

Sample No.	J	K	L	M	N	O	P
Storage time in brine (months)	8	8	8	8	8	8	0
Approximate processing time (days)	8	8	8	8	8	13	7
Gain or loss in drained weight after processing (%)	26 gain	33 gain	29 gain	25 gain	26 gain	26 gain	14 loss

Figure 5, which was prepared by extracting values from Tables 1 and 2, shows the Brix/time relationships of samples A, B, C and D when processed at 120°F for about 4 days, and samples E, F, G and H when processed at 110°F for about 8–9 days. The variation in processing time to reach the desired Brix at each temperature was concluded to be due to the different weather conditions prevailing at the time.

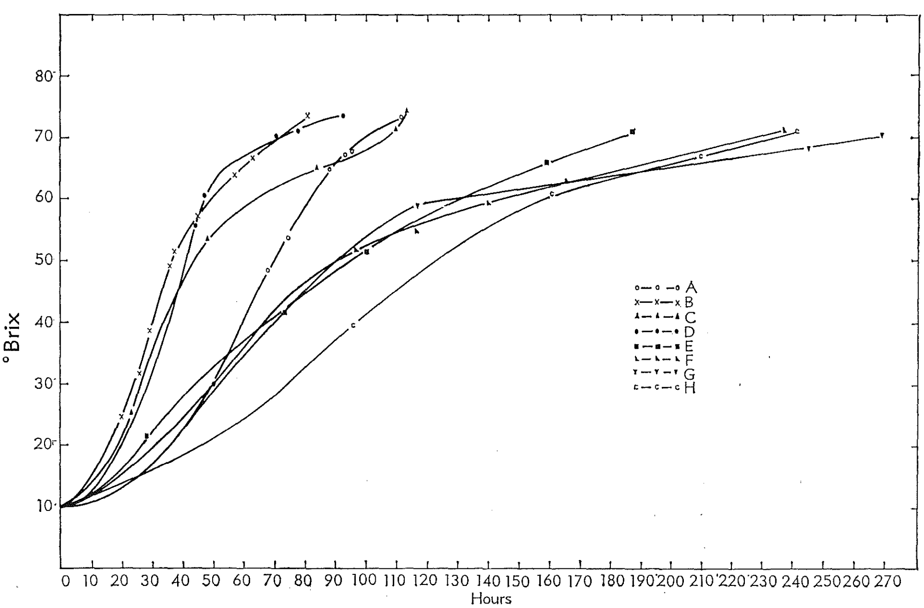

Fig. 5.—Changes in Brix with time of processing.

The lower temperatures used in this continuous evaporation process as compared with batch methods (Leverington 1969*a*) resulted in less caramelization and therefore lighter coloured ginger.

The addition of sulphur dioxide to the syrup was found unnecessary.

Power consumption for the evaporative syruper when loaded with 1,500 g ginger was approximately 3 kW. hours per pound of processed product. This is reasonable when it is considered that no labour is required during the syruping period of about 8–9 days, as the process is completely automatic once syruping commences.

V. CONCLUSIONS

The time of brining appears to have a bearing on recovery, Best recoveries were obtained by brining for about 8 months. More recent observations indicate that brining stringless ginger in excess of this period often softens the ginger, causing some disintegration during syruping.

The longer processing time, i.e. 8–9 days, gave a higher recovery than the shorter time of 4 days. Extension of processing time in excess of this period may increase yields slightly, but increased capital costs of storage and equipment on a commercial basis may not warrant the extension of time.

Under the conditions described, fibrous or stringy ginger can be expected to give higher yields than stringless ginger. It is assumed that this is due to the tougher texture of the former product.

A continuous and gradual rise in Brix can be expected to produce higher recoveries than the conventional process of daily boiling and adding sugar to the syrup drained from the ginger. The product can be expected to be lighter in colour also.

To install this type of syruper commercially would involve a high capital outlay, but the principle has been applied commercially by passing the syrup through a chain of tanks or continuously pumping the syrup alternately through tanks of ginger and over a steam-heated set of coils over which a fan is blowing. Whichever method is used, labour costs can be expected to be considerably lower than with batch methods.

An exudation of syrup and consequent loss in drained weight occurs when syrup is drained off for strengthening under the batch system. The continuous evaporation process overcomes this difficulty by keeping the ginger completely immersed during the syruping treatment. Compression of ginger also occurs during cooking when water is drained off and moisture is evaporated from the exposed hot surfaces.

The principle should be applicable to the crystallizing of fruits, provided adequate provision is made to prevent fermentation.

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