

# WASHING WITH SYRUP IN A-BATCH CENTRIFUGALS

By G. R. E. LIONNET

Sugar Milling Research Institute

## Abstract

The possibility of using sugar liquors and evaporator syrup to replace water as the wash medium in batch A centrifugals is investigated both on a laboratory and full scale. It is shown that the use of syrup increases massecuite exhaustion, reduces crystal dissolution by about 30% and results in steam savings. The plant needed for syrup washing is simple and inexpensive. Finally, the possibility of conditioning the wash medium to improve sugar quality is briefly discussed.

## Introduction

The use of various sucrose solutions to replace water as washing medium in batch centrifugals is not a new concept. Hanson,<sup>2</sup> for example, reports that American refineries started using low coloured liquors as wash in the early 1940's. There was a significant energy saving but some lowering of quality.

A number of Russian workers show that refinery liquors can replace water in batch machines (Dmitrenko *et al.*;<sup>1</sup> Kovarik *et al.*;<sup>4</sup> Matvienko *et al.*;<sup>5</sup> Tereshin *et al.*<sup>7</sup>) Generally, the use of liquors increased the crystal yield and reduced steam consumption. Tereshin *et al.*<sup>7</sup> for example report a sugar yield increase of 0.02% and a saving of 1.2% steam, both on beet. These workers note, however, that the liquor wash must be followed by a short water wash.

More recently, Mosel *et al.*<sup>6</sup> have investigated the use of different liquors for the washing of white and raw sugars under industrial conditions. Under optimum conditions the use of syrup resulted in a one-third reduction in the amount of wash medium, simultaneously increasing the crystal yield.

In South Africa, Jullienne<sup>3</sup> has investigated the use of water as washing medium in A-centrifugals. He shows that steam and water were of equal efficiency and that at the minimum VHP pol specification about 3% of the crystal was dissolved by the washing step.

This brief review of the literature shows that it is possible to use liquors or syrups to replace water, at least partly, as a washing medium. The resulting advantages would include higher exhaustions and steam economy.

## Experimental procedures

### Laboratory Tests

The use of syrup or liquors was first tested on a laboratory scale. This offers a number of advantages such as experimental flexibility, the possibility of getting precise mass balances and easy sampling. The equipment used included a laboratory centrifugal curing 2 kg of massecuite per charge and a 2-litre capacity wash application system.

The massecuites used for the laboratory tests were made by mixing sugar and molasses as required. The washing media consisted of water, syrups or liquors. All the tests were done at room temperature.

### Factory Tests

The equipment used in the laboratory was also used during factory tests. For those tests, however, catch samples of factory A-massecuites and evaporator syrups were used. As far as possible the temperatures of these materials were kept as close as possible to those found in the plant.

Two types of full-scale tests were then done. At IL and NB temporary arrangements were made to allow syrup washing in one of the A-machines. The results obtained from that machine, under full scale operation, were then compared to those of the other A-machines, treating the same A-massecuite. These tests lasted 1-2 hours.

At MS a permanent, full-scale plant was installed by the factory. This allowed syrup washing to be applied to the total amount of A-massecuite cured, over continuous periods of up to 4 hours. At all factories the nozzles installed for water were used for syrup and found to be adequate.

## Results and Discussion

### Laboratory tests

Since the laboratory tests were done with artificial massecuites cured at room temperature, the results cannot be applied directly to factory conditions but allow comparisons between the effects of syrup and water.

Two quantities, namely % colour reduction and pol in molasses % pol in massecuite, which are derived in Appendix 1, are used to investigate the effects of water and of a 40 brix sugar liquor on the curing of the same massecuite.

The amounts of water and 40 brix liquor wash required to achieve the same colour reduction in the sugar produced are given in Table 1.

Table 1  
Sugar colour reductions with water and 40 brix liquor wash

% colour reduction	Wash % massecuite	
	Water	40 brix liquor
20	0,6	1,2
40	1,4	2,5
60	3,6	5,5
80	8,9	11,8

It is evident that, for the same colour reduction, more liquor is needed than water.

Equations 1 and 2 show the relation between the pol lost in molasses and the sugar colour reduction with water and 40 brix liquor wash respectively:

$$\text{pol in mol. \% pol in m/c} = 24,6.e^{(0,008897 \times \% \text{ col. red.})} \dots \dots \dots (1)$$

(n = 18; r = 0,90)

$$\text{pol in mol. \% pol in m/c} = 28,2.e^{(0,005765 \times \% \text{ col. red.})} \dots \dots \dots (2)$$

(n = 22; r = 0,84)

These results are presented graphically in Figure 1 and show that for colour reductions above about 45%, the liquor wash is more efficient than the water one. Lower crystal dissolutions are thus expected with liquor wash.

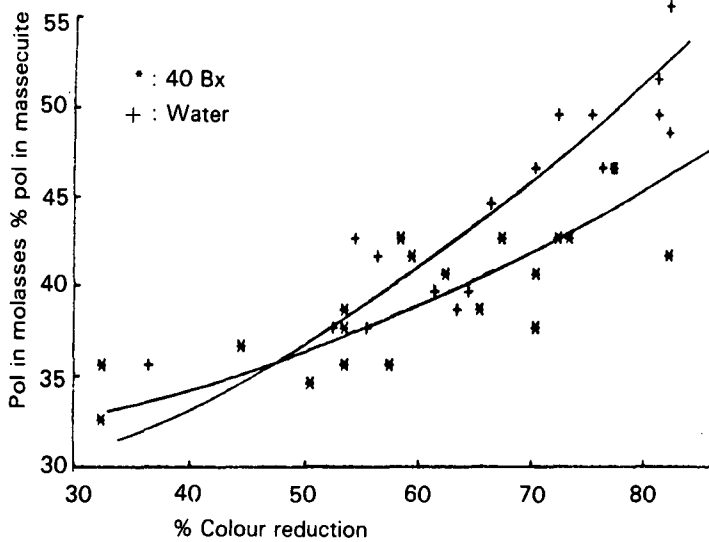


FIGURE 1 Pol in molasses percent pol in massecuite plotted against percent colour reduction in sugar, with water and liquor wash

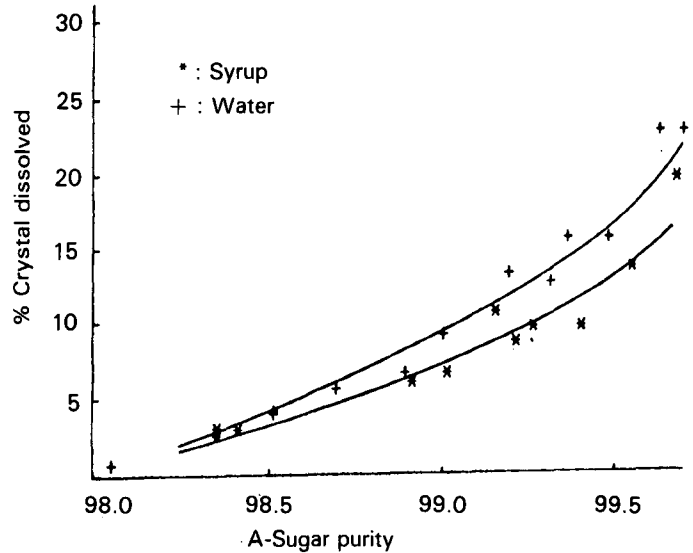


FIGURE 2 Crystal dissolution plotted against sugar purity with water and syrup wash

**Factory Tests**

Tests were carried out at Illovo and Noodsberg involving the curing of catch samples of the mill's A-massecuite in the laboratory centrifugal. Hot evaporator syrup, diluted to 50 Brix and hot water were used as wash media.

Five series of tests, over a period of 5 days, were done at Illovo. Basic massecuite and syrup qualities are given in Table 2.

Table 2  
Syrup and massecuite used at Illovo in the pilot centrifugal

Series	1	2	3	4	5
A massecuite temperature (°C)	56	60	60	61	61
A massecuite brix	93,6	94,2	92,9	93,0	93,0
A massecuite purity	86,5	86,3	86,1	85,8	86,5
Syrup brix	47	48	49	50	48

Jullienne<sup>3</sup> gives a formula, based on purities, to calculate the percentage of crystal dissolved during the washing process. This formula was used here to calculate the crystal dissolution as a function of sugar purity.

Equations 3 and 4 were obtained for water and syrup wash respectively.

$$\text{Crystal dissolved \% crystal in m/c} = -6119 + 1334.\ln(\text{Sug. pur.}) \dots\dots\dots(3)$$

(n = 12; r = 0,92)

$$\text{Crystal dissolved \% crystal in m/c} = -4146 + 904.\ln(\text{Sug. pur.}) \dots\dots\dots(4)$$

(n = 12; r = 0,92)

These results have been plotted in Figure 2.

For a sugar purity of 99,5 the use of syrup reduces the crystal dissolution from 18 to 13%.

Three series of tests were carried out at Illovo, where one factory A-centrifugal, using syrup wash, was compared to the other machines using water. Undiluted, hot syrup was used. Some basic data are given in Table 3.

Table 3  
Full scale tests at Illovo

	Brix	Purity	Temperature (°C)
A massecuite	93,0	85,0	—
A nutsch	—	58,0	—
Wash syrup	60	—	50°C

The A-machine using syrup cured 1000 kg of massecuite per cycle and the average mass of syrup used was 16 kg, which corresponds to about 1,6 syrup wash % massecuite. The syrup wash was followed by a 1 second water wash addition and steam was used throughout the cycle. The machines using water wash also had steam throughout the cycle. The results obtained are shown in Table 4:

Table 4  
Syrup and water wash, full scale tests at Illovo

	Syrup wash			Water wash		
	Sugar purity	A molasses brix	A molasses purity	Sugar purity	A molasses brix	A molasses purity
Test 1	99,76	79,0	61,9	99,77	77,8	62,3
Test 2	99,47	79,9	60,1	99,35	78,2	61,2
Test 3	99,38	80,0	59,3	99,52	78,0	60,6
Average	99,53	79,6	60,4	99,55	78,0	61,4

Again using Jullienne's<sup>3</sup> crystal dissolution formula, it can be calculated that the water wash resulted in a 4,8% crystal dissolution while the syrup value was 3,3% or a 30% improvement.

The results in Table 4 also show that the use of syrup resulted in a higher A-molasses brix and a lower purity.

A similar test was done at Noodsberg, using hot, 66 brix syrup. No water wash was used after the syrup and no steam was applied either in the syrup or water machines. A water flush was, however, used in all the machines, after ploughing. This consisted of a 6-second spray (approximately 6-8 litres of water).

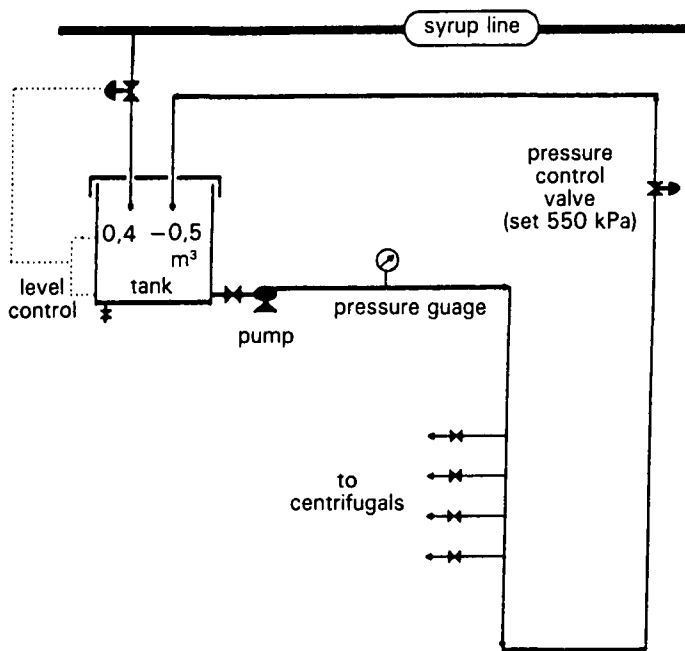
The results obtained are shown in Table 5.

**Table 5**  
Syrup and water wash, full scale tests at Noodsberg

Syrup wash			Water wash		
Sugar purity	A molasses brix	A molasses purity	Sugar purity	A molasses brix	A molasses purity
99,37	69,0	71,5	99,51	67,7	73,0

Taking into consideration the fact that the sugar purities are not the same, the 1,5 unit difference in A-molasses purity appears too high. A 1 unit drop would be more realistic, which also agrees well with the value found at Illovo.

A permanent, full-scale syrup wash system was installed by Maidstone, which allowed either 50% or 100% of the A-masseccuite to be cured with syrup wash. A schematic diagram of this system is shown in Figure 3.



**FIGURE 3** Schematic diagram of syrup wash plant at Maidstone

The results given below were obtained when the total A-masseccuite throughput was cured with syrup wash for continuous periods of up to 4 hours. No water was used after the syrup wash but steam was added throughout the cycle. The baskets were sprayed with hot water at regular intervals. For comparison purposes, water wash runs were carried out for short periods during the tests.

Again the sugar purities are not the same. The 1,3 difference in molasses purity could be inflated and 1-unit change would be more appropriate.

The amount of water used during those tests was around 4% on masseccuite, while syrup was about 6,5%. These figures are high but were necessary to produce the required sugar pol and colour.

Some basic data are given in Table 6.

**Table 6**  
Full-scale syrup wash at Maidstone

	Brix	Purity
A masseccuite	91,5	84,5
Nutsch	—	60,0
Syrup	67,0	—

The results obtained are shown in Table 7.

There was no evidence of handling or drying problems for the sugar produced during those tests.

*Syrup Conditioning*

The use of syrup for washing A-sugar offers the possibility of conditioning the syrup, for example in terms of colour.

Preliminary tests done at the SMRI, involving a lithium tracer and wash liquids of different colour levels, indicated that, as sugar purity rises, the amount of wash liquid remaining with the sugar increases. Thus, the quality of the wash material influences the final sugar quality. It could therefore be worthwhile to decolorise the syrup or, in factories with back end refineries, to use a low colour liquor as wash.

**Conclusions**

The results obtained in the full scale tests show that syrup washing offers the following advantages:-

- The conventional A-masseccuite exhaustion can be calculated to rise by about 1 to 1,5 units.
- There is a 30% reduction in the amount of crystal sugar dissolved in the centrifugal. This has two advantages. Firstly it saves energy since that amount of sugar does not have to be recrystallised and secondly it reduces undetermined losses through the recirculation of that sugar.
- Energy is saved since no additional water is now added to the A-molasses. Syrup would anyhow have to be evaporated. During these tests, water % masseccuite averaged 2,1% whereas syrup % masseccuite was 3,0%. Assuming 1 m<sup>3</sup> of A-masseccuite per ton of Brix in mixed juice, 1,4 tons of water or 1,9 tons of syrup per hour would be required, on average. The evaporation of 1,4 tons of water per hour in the pans is now eliminated.
- The possibility of using conditioned syrup could result in improved sugar quality. This, however, needs to be investigated in more detail.

On the negative side, the installation and maintenance of the syrup wash plant is obviously required.

As is evident from Figure 3, the installation is neither complicated nor costly. It is felt that the costs of the plant and any other modifications would be quickly recovered through the savings mentioned earlier.

**Table 7**  
Results of full-scale tests at Maidstone

	Syrup wash				Water wash			
	Sugar purity	Molasses brix	Molasses purity	Crystal dissolved % crystal in masseccuite	Sugar purity	Molasses brix	Molasses purity	Crystal dissolved % crystal in masseccuite
Ave. of 4 runs	99,29	80,2	64,8	8,4	99,47	79,4	66,1	11,2

### Acknowledgements

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### APPENDIX 1

Derivation of % colour reduction and pol in molasses % pol in massecuite

#### 1. % colour reduction.

Let A sugar colour without any wash be 2 240 units. A sugar colour with 3% water on massecuite is 1 080.

$$\text{Then \% colour reduction} = \frac{(2\,240 - 1\,080)}{2\,240} \times 100$$

$$= 52\%$$

#### 2. Pol in molasses % pol in massecuite

Mass massecuite used 2 100 g. Pol % massecuite = 70,1.

Mass wash syrup used 64 g. Pol % syrup = 60,0

Mass molasses = mass massecuite + mass wash - mass sugar

$$= 2\,100 + 64 - 1\,000$$

$$= 1\,164\text{ g}$$

Pol % molasses = 49,4

Mass pol in molasses = 575 g

Mass pol in syrup = 38 g.

∴ Mass pol in molasses from massecuite = 575 - 38

$$= 537\text{ g.}$$

$$\text{Then pol in molasses \% pol in massecuite} = \frac{537 \times 100}{2\,100 \times 0,701} = 36,5$$

As sugar purity rises, the amount of pol in the molasses will rise firstly because more molasses is being removed from the sugar but also because the sugar itself is being dissolved by the wash material.