Clarification of Cashew Apple Juice by Crossflow Microfiltration: Foulant Fractions and Interest of Filterability Tests

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CROSSFLOW microfiltration (CMF) is more and more used for juices clarification and sterilization. If this process presents many advantages (e.g. cold operating conditions), the membrane fouling can limit considerably the permeate flux during clarification operation. The objective of this study is first to determine the main foulant fractions of cashew apple juice and then to implement tests of filterability in order to predict the filtration performance during filtration running's.

Materials and methods

- Raw material: yellow and red cashew apples from Yamoussoukro (Côte d'Ivoire).
- Crossflow microfiltration trials: 4 tubular ceramic membranes (55 cm^2, 0.2 µm), U = 6 $m.s^{-1}$, T= 35 ± 2°C, TMP = 2 bar.
- Three juices used to evaluate the foulant fraction (fig. 1).
- Filterability tests:
  - Specific resistance of filtration (SRF) with Amicon cell: cellulose acetate membrane, 0.2 µm, agitation, T= 35 ± 2°C, P = 2 bar.
  - Capillary suction time (CST): CST-meter, Triton type 319 Multi-CST (Triton Electronics Limited); T= 35 ± 2°C.

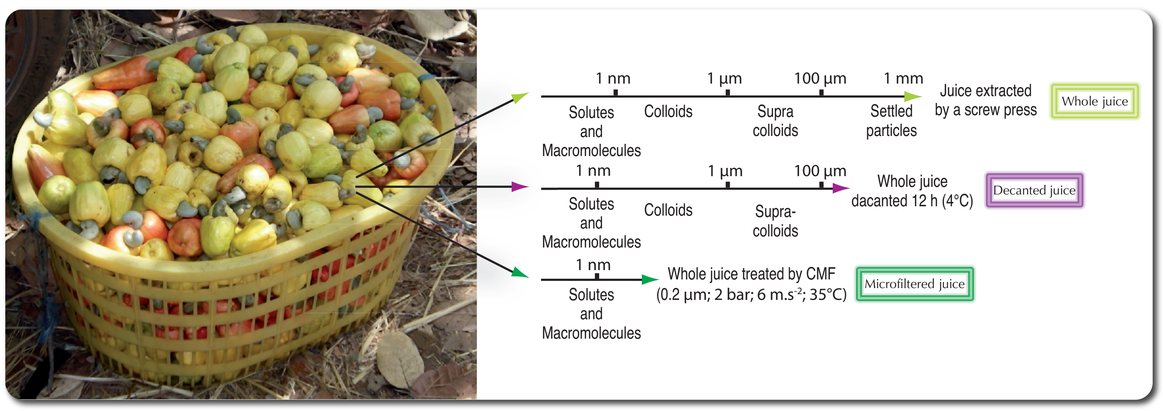

Figure 1. The three types of juices treated.

Results and discussion

All tannins, suspended insoluble solids and alcohols insoluble solids (mainly polysaccharides) were totally retained by the membrane. Sugars, ascorbic and other acids were preserved in the permeate (table I).

Table I. Main characteristics of cashew apple juice.

Juices	Whole	Decanted	Microfiltered
pH	4.05	3.90	4.06
Titratable Acidity (g malic acid.kg^{-1})	29.4	26.1	26.6
Total Soluble Solids (g.kg^{-1})	52	56	56
Suspended insoluble solids (g.kg^{-1})	7.8	3.3	0
Tannins (g.kg^{-1})	23.1	2.1	0
Alcohols insoluble solids (g.kg^{-1})	3.8	0.3	0
Viscosity at 35°C (mPa.s^{-1})	1.2	1.1	1.1
Turbidity (NTU)	8 033	233	6
Ascorbic acid C (g.kg^{-1})	15.0	14.2	14.1

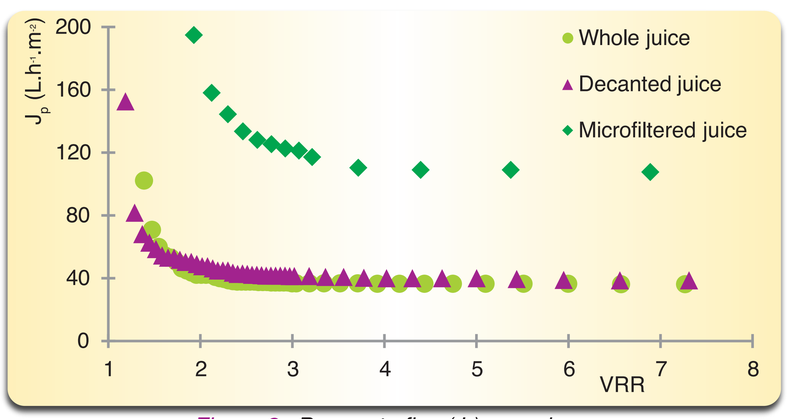

Figure 2. Permeate flux (J_p) vs. volume reduction ratio (VRR) for the cashew apple juices.

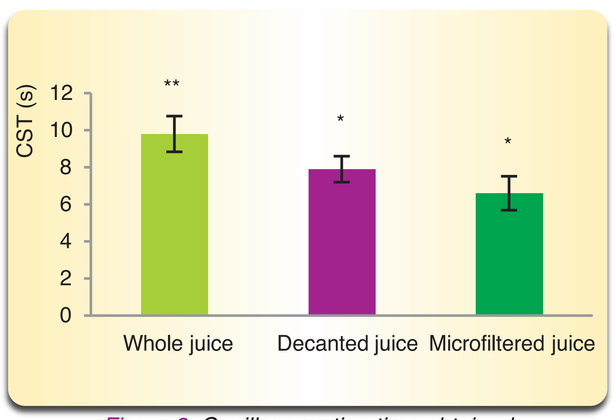

Figure 3. Capillary suction time obtained with the different cashew apple juices.

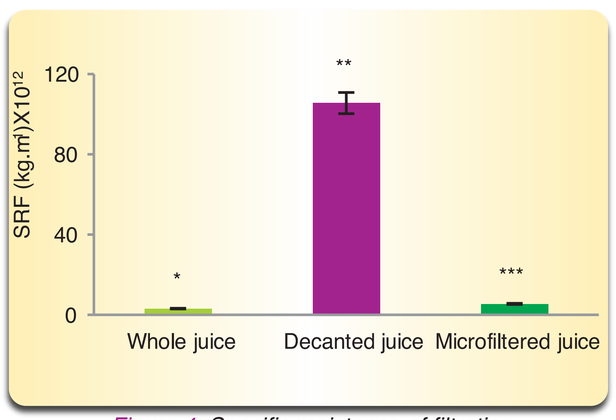

Figure 4. Specific resistance of filtration obtained with the different cashew apple juices.

Filterability tests:
- According CMF: whole juice = decanted juice < microfiltered juice (fig. 2).
- According CST: microfiltered juice = decanted juice < whole juice (fig. 3).
- According SRF: decanted juice > microfiltered Juice > whole juice (fig. 4).

No correlation between the filtration performances and conventional filterability tests

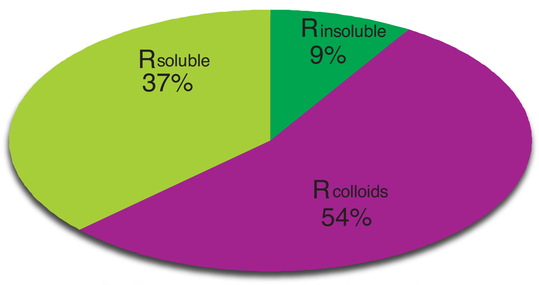

Figure 5. Contribution of the different foulant fractions to the total hydraulic resistance during CMF of the cashew apple juices (VRR 8).

The resistance in serial model was used to evaluate the contribution of the different foulant fractions (eq.1). We demonstrated the major role of the colloidal fraction of cashew apple juice in membrane fouling (fig. 5).

$$R_f: \frac{TMP}{\mu x J_p} - R_m \text{ and } R_f = R_{soluble} + R_{colloids} = R_{insoluble} \quad \text{(eq. 1)}$$

R_m: the membrane resistance (m^{-1}); R_f: the fouling resistance (m^{-1}); µ: dynamic viscosity of the permeate (Pa.s)

Conclusion

Crossflow microfiltration can be used to clarify cashew apple juice (reduction of tannins and so astringency). The main foulant substances seem to be colloids (54% of the fouling resistance). The filtration performances cannot be predicted by filterability tests like CST or SFR. New filterability test has to be developed. Further study is needed in order to better understand the fouling phenomena.

Conception: CIRAD, Marine Dupont, October 2012 — photos © D. Soro