The making of healthy and colorful fruit juices and purees under oxygen-exclusion with spiral filter press

A. Wagner, P. Bach, M. Ludwig, F. Will, R. Schweiggert
Analysis & Technology of Plant-based Foods
Department of Beverage Research, Hochschule Geisenheim University
Von Lade-Straße 1, D-65366 Geisenheim, Germany

Introduction

The focus of this work was the vacuum-driven spiral filter system (Fig. 1), which allows the production of juices and purees derived from fruit and vegetable raw materials. Unlike conventional processes, all processing steps from crushing to filling take place in a low-oxygen atmosphere and in a rapid, continuous process sequence.

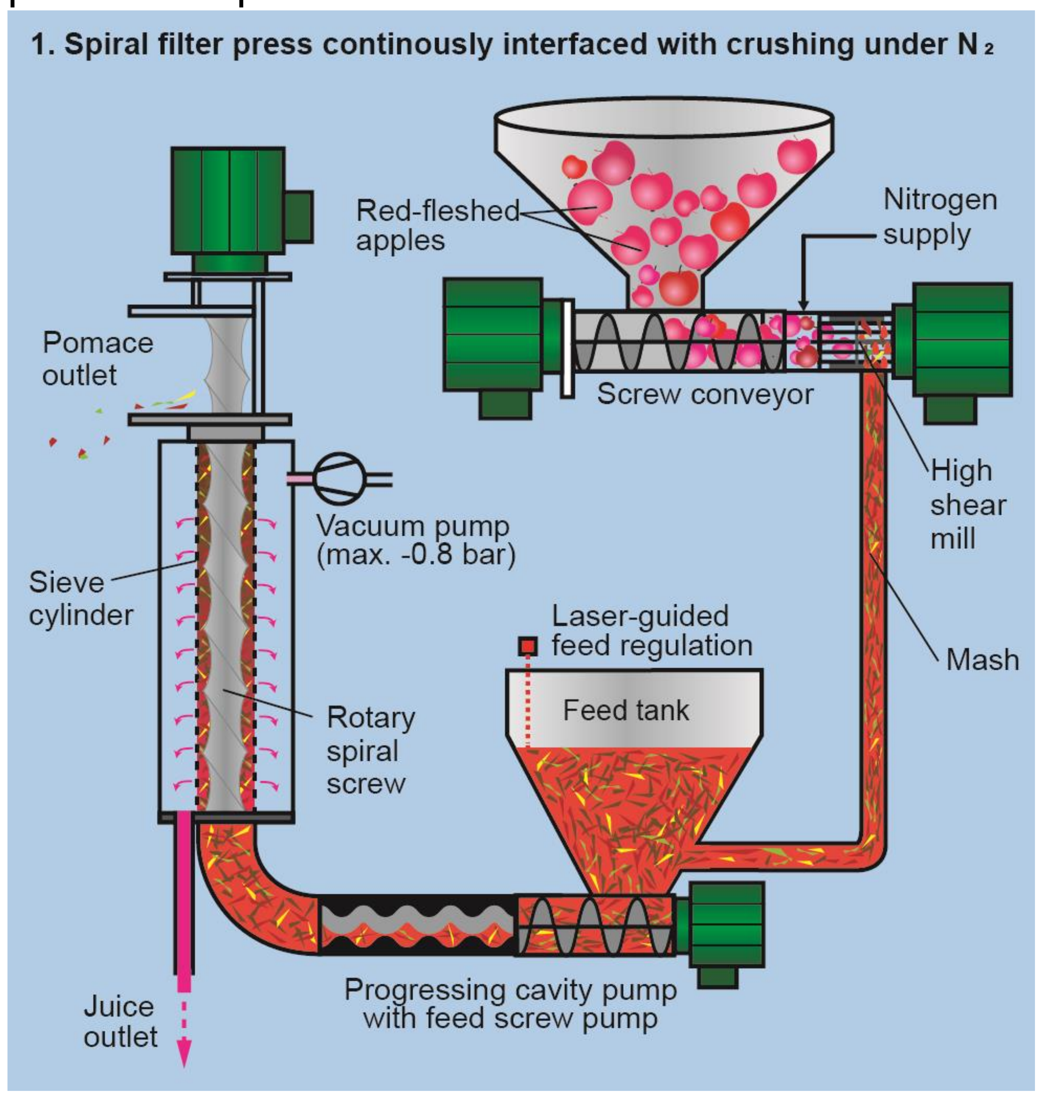

Fig. 1 Technological steps of spiral filter system.

Objective

The spiral filter technology was used for processing of red-fleshed apples (*Malus domestica* L. cv. 'Weirouge') and blackcurrants (*Ribes nigrum* L.) to cloudy juice. The research aims were to investigate whether processing with a spiral filter press allows a lower oxygen input into the product and thus leads to improved yield and preservation of oxidation sensitive ingredients and a better color retention compared to conventional solid-liquid separation processes.

Materials and Methods

In the processing carried out using (Fig. 1) spiral filter technology (VaculiQ-1000, Hamminkeln/DE) as well as the conventional juice extraction systems horizontal filter press (HP-L 200, Bucher, Niederweningen/CH) and decanter (Z23-3, Flottweg, Vilsbiburg/DE), two vintages of red-fleshed apples and blackcurrants were processed into cloudy juices in two technical replicates (n=2) per year and technology. In a subsequent stability study, changes in oxygen labile compounds and color were monitored over a period of up to 12 months at three temperatures (4, 20 and 37°C).

Anthocyanins from blackcurrants juice were isolated using an adsorber resin column (BPG 140/950, Pharmacia, Uppsala/SE) and the isolates were used for preparation of artificial model solutions containing anthocyanins, ascorbic acid and dissolved oxygen at different levels for investigating the influence of those factors as well as pH value on anthocyanins during heating at 80°C. The small-scale experiments followed a D-optimal experimental design.

Analytics

For measuring the oxygen dissolved in the juices, a galvanic measuring system (CellOx 325 and Oxi 3310, WTW, Weilheim/DE) was used. Color was determined spectrophotometrically by measuring the absorption over a range of 380 to 770 nm (UV 500 UV/VIS spectrophotometer, Unicam, Georgensmünd/DE) and calculation of L*a*b* values. Ascorbic acid was determined potentiometrically (IFU method no. 17). Total phenol measurement was carried out photometrically with the Folin-Ciocalteu reagent according to Singleton and Rossi (1965) with catechin as reference. For identification of anthocyanins and colorless (poly)phenols, an UHPLC-DAD-ESI-QTOF-HR-MS/MS system (Bruker Daltonik, Bremen/DE) equipped with a C18-column (Reprosil-Pur 120 ODS-3, 125×2 mm, 5 µm particle size, Dr. Maisch, Ammerbuch/DE) with a guard cartridge of the same material was used, quantification was carried out using a UHPLC-DAD system (UltiMate 3000, Thermo Fisher, Waltham/US).

Results

Red-fleshed apples ‚Weirouge' [1]

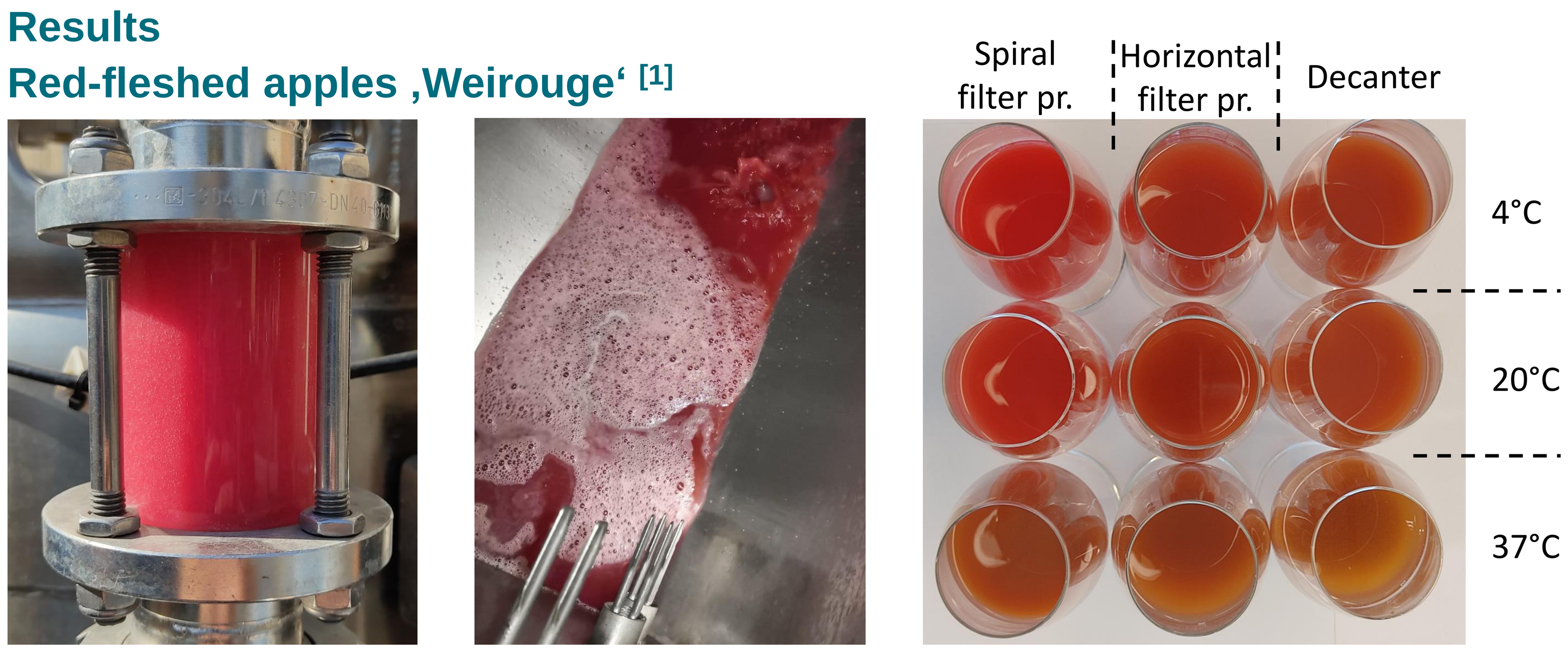

Fig. 2: Sight glass spiral filter press (l.), juice basin horizontal filter press (m.), juices after 12 month of storage (r.).

Clear differences in color and oxygen content were observed in the freshly pressed juice (Fig. 2) derived from the three pressing systems. The spiral filter pressed juices had a more appealing red color (CIE-a*) and less pronounced brown hues apart from significantly higher contents in ascorbic acid, anthocyanins and total phenols (Tab. 1) compared to the reference variants. These observations were maintained over a storage period of 6 month.

Tab. 1: Levels of oxygen, ascorbic acid, CIE-a* and (poly)phenolic compounds in raw juice derived of dejuicing redfleshed apples with three different pressing systems in 2019 (n = 2 technological replicates) and 2020 (n = 2).

	2019			2020		
	Spiral filter press	Horizontal filter press	Decanter	Spiral filter press	Horizontal filter press	Decanter
oxygen [mg/L] after pressing	n.a.	n.a.	n.a.	4.5 ± 0.1 ^{b}	6.1 ± 1.1 ^{b}	10.7 ± 0.0 ^{a}
ascorbic acid [mg/L]	21.0 ± 2.8 ^{a}	5.5 ± 0.7 ^{b}	4.5 ± 0.7 ^{b}	39.6 ± 8.3 ^{a}	10.7 ± 1.5 ^{b}	7.5 ± 0.6 ^{b}
total phenols [mg/L]	795 ± 7 ^{a}	405 ± 11 ^{b}	425 ± 10 ^{b}	960 ± 122 ^{a}	533 ± 27 ^{b}	617 ± 72 ^{ab}
CIE-a*	26.3 ± 0.6 ^{a}	7.4 ± 0.1 ^{b}	5.5 ± 0.9 ^{b}	30.5 ± 3.5 ^{a}	11.4 ± 0.6 ^{b}	13.3 ± 3.1 ^{b}
tot. anthocyanins [mg/L]	47.89 ± 0.06 ^{a}	14.61 ± 0.04 ^{b}	12.59 ± 0.04 ^{b}	74.91 ± 0.10 ^{a}	17.26 ± 0.02 ^{b}	17.19 ± 0.35 ^{b}
tot. colorless (poly)phenols	169.60 ± 0.61 ^{a}	74.06 ± 0.25 ^{b}	78.04 ± 0.08 ^{b}	323.53 ± 0.48 ^{a}	13.89 ± 0.36 ^{b}	15.93 ± 1.28 ^{b}

Superscript letters (a, b) indicate significant ($p < 0.05$) differences of means within one year. n. d.: not detected.

Blackcurrants [2]

Processing parameters and stability study

In blackcurrant raw juices, lower oxygen contents were seen in spiral filter pressed juice (2.8-3.3 mg/L) compared to horizontal filter and decanter made juices (4.7-10.1 mg/L). However no significant differences were seen for color (CIE-a* 43.0-48.4) and amounts of ascorbic acid (2095-2213 mg/L in 2019 and 1455-1877 mg/L in 2020), anthocyanins (1529-1636 mg/L in 2019 and 1872-2083 mg/L in 2020) and total phenols (5657-5922 mg/L in 2019 and 6929-7300 mg/L in 2020). It was assumed that the high ascorbic acid levels in blackcurrants mitigated any oxygen caused effects.

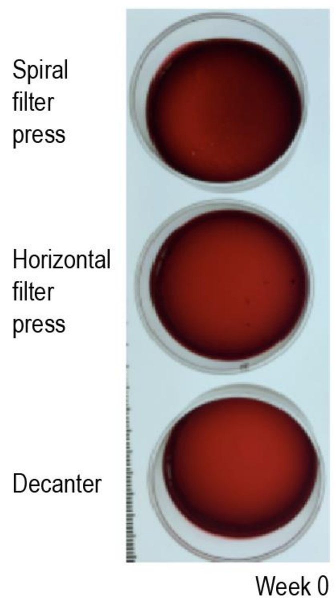

Fig. 3: Blackcurrant raw juice in 2020.

Systematic investigation of factors influencing the stability of blackcurrant anthocyanins

At low (juice-like) pH, ascorbic acid negatively influenced anthocyanin stability (Fig. 4 A). The negative impact caused by ascorbic acid was less pronounced at higher sugar concentrations.

At higher pH values, an inverted behavior was seen. Increased sugar contents intensified anthocyanin degradation (Fig. 4 B). Enhanced Maillard reactions at high pH were suspected to lead to anthocyanin degradation by carbonyl compounds.

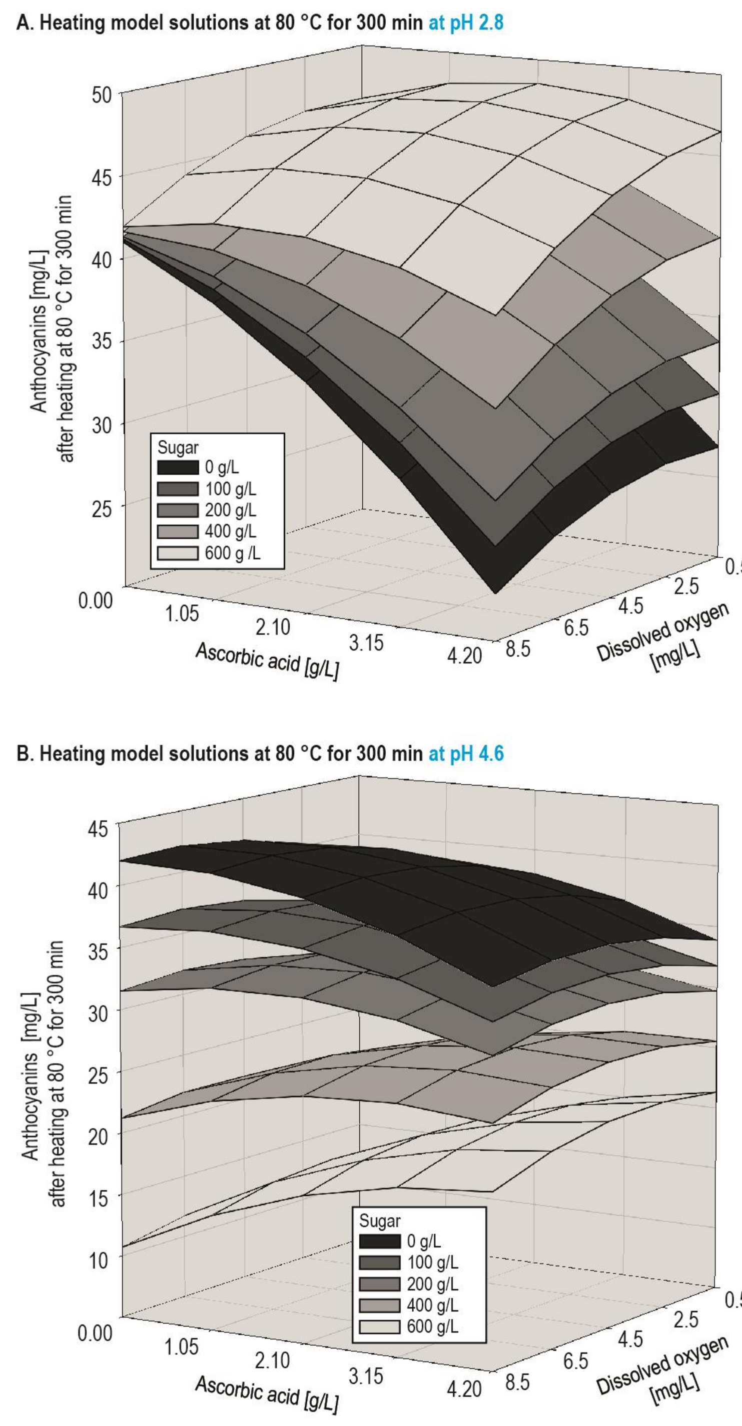

Fig. 4: Response surface plot illustrating the effect of dissolved oxygen, ascorbic acid and total sugars on blackcurrant anthocyanins after heating model solutions at 80°C for 300 min at pH 2.8 (A) and pH 4.6 (B).

Conclusion

As shown for juices produced from red-fleshed apples significantly more attractive color and higher contents of oxidation-sensitive compounds, both after processing and over the entire storage period, were seen in spiral filter pressed juice compared to conventionally produced juice.
For blackcurrants the spiral filter technology offered only marginal advantages during processing and storage.

Depending on the raw material used, the spiral filter technology thus proves to be promising for gentle processing of fruits and vegetables into premium juices allowing attractive color and high retention of oxidation-sensitive constituents during processing and storage.
The findings on the blackcurrant anthocyanins and their interaction with ascorbic acid, oxygen, sugar and pH provided new insights particularly into the role of ascorbic acid, but further research is needed.

References

[1] Wagner A, Dussling S, Scansani S. *et al.* Comparative evaluation of juices from red-fleshed apples after production with different dejuicing systems and subsequent storage. *Molecules*. 2022; 27(8):2459. https://doi.org/10.3390/molecules27082459

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Bundesministerium für Wirtschaft und Klimaschutz

Annette Wagner
Hochschule Geisenheim University
Von-Lade-Str. 1 | D-65366 Geisenheim
T. +49 6722 502 314
annette.wagner@hs-gm.de