Ozone as an alternative method to control postharvest diseases on apples

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Introduction

Substantial fruit losses are caused by the development of fungal diseases during storage. Chemically synthetized treatments are today the most effective methods to prevent fungal diseases on apples but their application is more and more restrictive in conventional agriculture and prohibited in organic crops. Alternative methods are therefore needed to better control postharvest diseases and to mitigate the risks of high economical losses after harvest.

Objective of the study

To evaluate the effect of a treatment with gaseous ozone on the development of decay and the quality of apples during cold storage.

Material and methods

Different ozone treatments were tested on the apple cultivars 'Topaz' and 'Otava' harvested in 2017 and 2018 and stored at 4 °C for 6 months in experimental units (Table 1 and Fig. 2C). The influence of the treatments was evaluated on the development of decay, physiological disorders and fruit quality expressed in terms of firmness, total soluble solids (TSS), acidity and texture.

2017-18		2018-19	
1	0.5-1 ppm O3, daily	5	0.5-1 ppm O3, daily
2	1-2 ppm O3, every 2 days	6	0.05-0.1 ppm O3, daily
3	1-2 ppm O3, every 4 days	7	0.05-0.1 ppm O3, twice a week
4	Control	8	Control

Table. 1. Ozone treatments performed in 2017-18 and 2018-19 on 'Topaz' and 'Otava' apples cultivars.

Results

Apples were mainly affected by **bitter rot**. Percentage of decayed apples was reduced by half on average after 6 months of storage at 4 °C with ozone concentrations between 0.5 and 2 ppm (2017-18). The lower concentrations of ozone tested in 2018-19 (0.05 to 1 ppm) were less effective to limit development of this disease (Fig. 1).

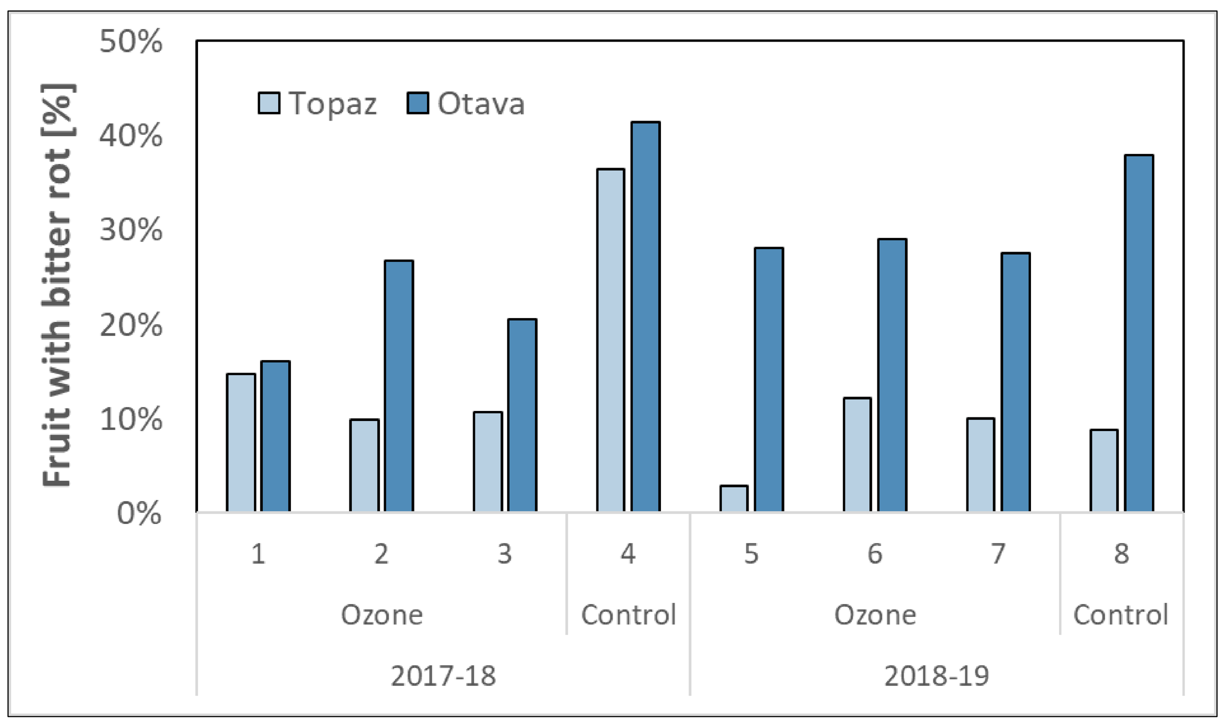

Fig. 1. Influence of ozone treatments on the development of bitter rot on apples after 6 month of storage at 4 °C.

			Firmness [kg/cm^2]		TSS [°Brix]		Acidity [g/L]		Texture of the skin F_p^1 [N]		Texture of the flesh F_p^{max} [N]	
			Topaz	Otava	Topaz	Otava	Topaz	Otava	Topaz	Otava	Topaz	Otava
2017-18	Ozone	1	5.1^a	4.8^a	12.1^a	10.8^b	7.1	6.0				
		2	5.3^a	4.7^a	11.4^b	11.4^a	5.2	6.3				
		3	5.2^a	4.9^a	11.5^b	10.7^b	5.3	5.8				
	Control	4	5.4^a	4.8^a	11.3^b	11.0^{ab}	5.9	6.5				
2018-19	Ozone	5	5.6^A	4.9^A	12.8^B	16.4^A	4.7	5.1	0.47^A	0.66^A	48.40^A	43.93^A
		6	5.6^A	4.7^A	13.5^A	15.8^{AB}	4.9	5.1	0.49^A	0.65^A	49.39^A	42.46^A
		7	5.5^A	4.2^A	12.9^B	15.1^B	4.5	5.2	0.46^A	0.63^{AB}	48.72^A	39.55^B
	Control	8	5.6^A	4.6^A	13.4^A	16.2^{AB}	4.6	4.9	0.48^A	0.61^B	49.02^A	41.38^{AB}

Table 2. Influence of ozone treatments on fruit quality (firmness, TSS and acidity) and fruit texture of the skin (F_p^1) and of the flesh (F_p^{max}) after 6 month of storage at 4 °C. Means with the same letters are not significantly different at $p \leq 0.05$ according to Tukey test.

Fruit quality in terms of firmness was not affected by all tested ozone treatments (Table 2). The treatments influenced in a different manner TSS and acidity according to the cultivar and the year. The skin and the flesh of 'Otava' apples daily treated with ozone (conditions 5 and 6 in Table 1) required a stronger force to be punctured compared to control fruits. This was not observed for the cultivar 'Topaz'.

Physiological disorders induced by ozone were mainly **"lenticel breakdown"** on 'Otava' and **greasiness** on 'Topaz' (Fig. 2A and 2B). These disorders were more substantial at high doses and frequencies of ozone application.

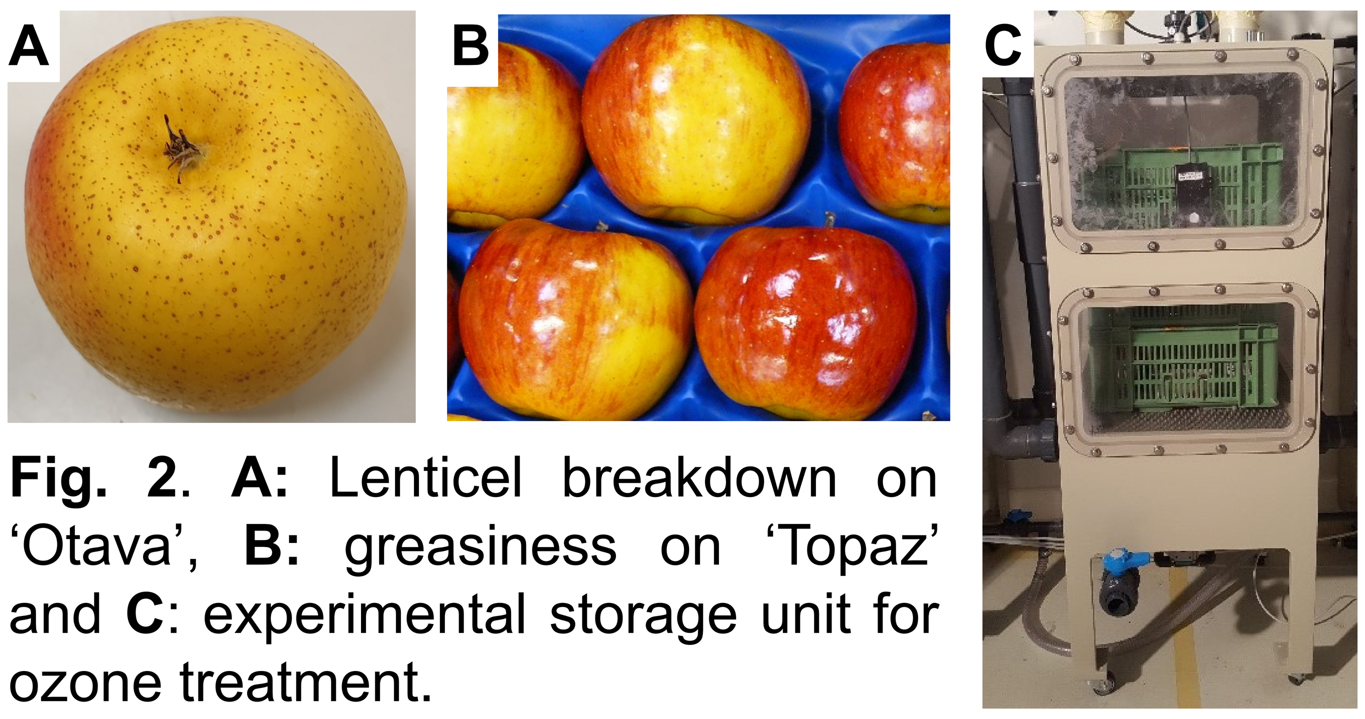

Fig. 2. **A:** Lenticel breakdown on 'Otava', **B:** greasiness on 'Topaz' and **C**: experimental storage unit for ozone treatment.

Conclusions

- Gaseous ozone treatments applied at 0.5 to 2 ppm were more effective to limit bitter rot development on apples compare to lower concentrations (0.05 to 1 ppm).
- Fruit firmness was not affected by ozone treatments. TSS and acidity were influenced in a different manner according to the cultivar and the year.
- Lenticel breakdown on 'Otava' and greasiness on 'Topaz' were induced by ozone, in particular at high doses and frequencies of application.
- These results bring evidences that gaseous ozone treatment can help to reduce decay on apples and that the dosis and frequency of application are determinant for commercial fruit quality.

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