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Technical evaluation of a modular dryer for medicinal and aromatic plants in practical German conditions

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I. INTRODUCTION

Drying medicinal plants is energy-intensive process. This study developed and tested a modular dryer (Fig. 1), using lemon balm to evaluate energy use and drying rates under two relative humidity (RH) control programs.

Fig. 1. Outside (left) and inside (right) view of the modular dryer during test runs in Vettweiß

II. METHODS

1. Plant material

Experiments took place at Rheinlandkräuter farm in Vettweiß, Germany, where lemon balm leaves grown on-site were dried using the modular dryer.

The dryer operated in three modes: (1) fresh air mode, (2) partial recirculation mode with controlled flap, and (3) full recirculation mode. Mode changes were based on the drying progress and the inlet relative humidity.

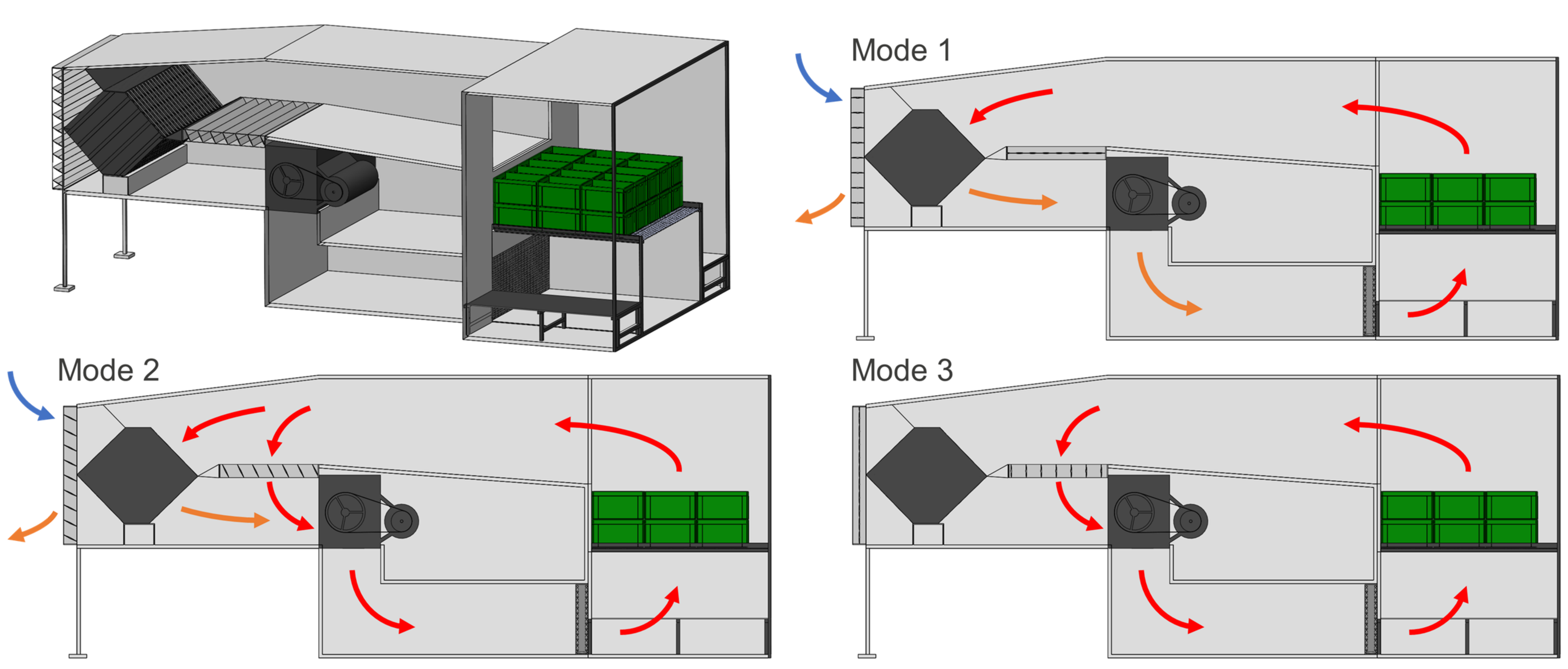

Fig. 2. CAD diagrams of the modular dryer and ist modes of control (1) fresh air, (2) recirculation and (3) full recirculation

2. Drying experiments

The experimental plan consisted of comparing two modes of relative humidity variation and assess the effect on energy consumption (Table 1).

Table 1: Experimental plan

Crop	Mode	Denomination
Lemon balm	Controlled flap with RH from 80-30 %	L1 and L2
Lemon balm	Controlled flap at RH of 40 %	L3 and L4

Temperature and humidity sensors monitored the air streams in the dryer. Moisture content was monitored by continuous weighing the boxes and final moisture content was confirmed using oven method. The essential oils content was also measured.

III. RESULTS AND DISCUSSION

Four drying lots of lemon balm were carried out at a target temperature of 45 °C, with approximately 500 kg of fresh leaves per lot (Table 2). Drying times ranged from 21 to 24 hours, except for the first drying lot, which took 38 hours due to uneven box filling.

Table 2: Drying time and throughput for lemon balm drying with partial air recirculation in 80-30 and 40 % modes

Mode	M_{in}, kg	M_{fin}, kg	MC_{in}, % $_{w.b.}$	MC_{fin}, % $_{w.b}$	Time, h	Throughput, kg.h^{-1}
L1-80/30	479.4	112.5	77.1	7.2	38.3*	12.5
L2-80/30	443.1	119.6	70.9	7.2	22	20.1
L3-40	472.2	125.9	70.7	7.1	24	19.7
L4-40	497.0	132.1	73.5	6.5	21	23.7

The throughput was estimated to 23.7 kg.h^{-1} for the fourth drying set.
The specific thermal energy consumption (STE) varied between 3330 and 375 kJ.kg^{-1} (Table 3).

Table 3: Energy requirement for drying lemon balm with partial air circulation in 80-30 % mode and in 40 % mode

Mode	M_w, kg	ΔT, °C	Q_{in}, kWh	M_{evap}, kg	STE, kJ.kg^{-1}
L1-80/30	73,492	5.6	480	366.9	4710
L2-80/30	42,529	6.3	309	323.5	3440
L3-40	46,201	6.7	361	346.4	3750
L4-40	40,103	7.3	338	364.9	3330

Fig. 3 shows the drying curves of various drying sets. Drying was faster in the bottom layers than in top layers.

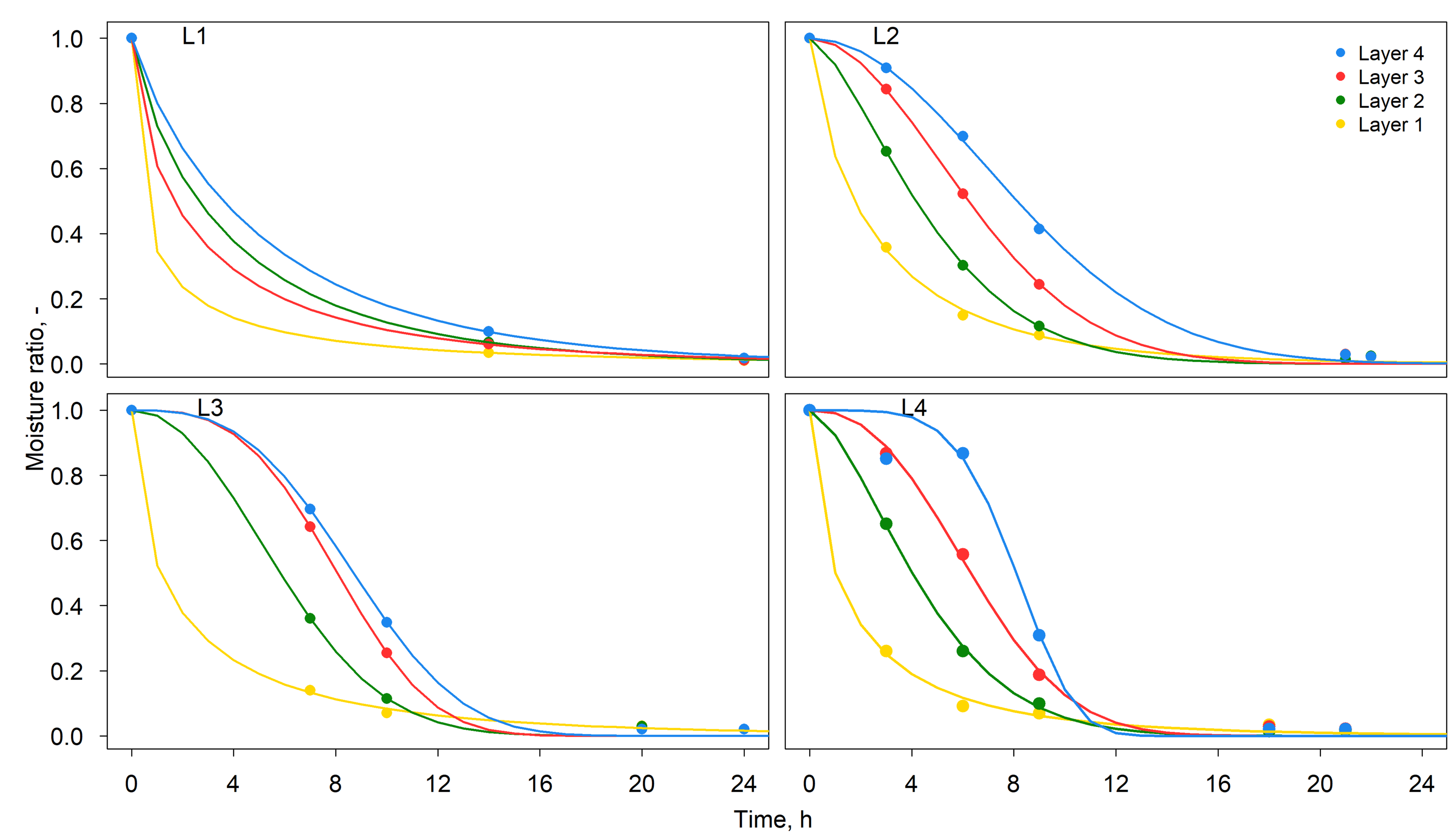

Fig. 3: Drying curves for lemon balm leaves in different layers

The oil content of lemon balm leaves varied from 0.12 % (V/m) to 0.04 % (V/m) with a greater reduction in the 80-30 % mode (Fig.4).

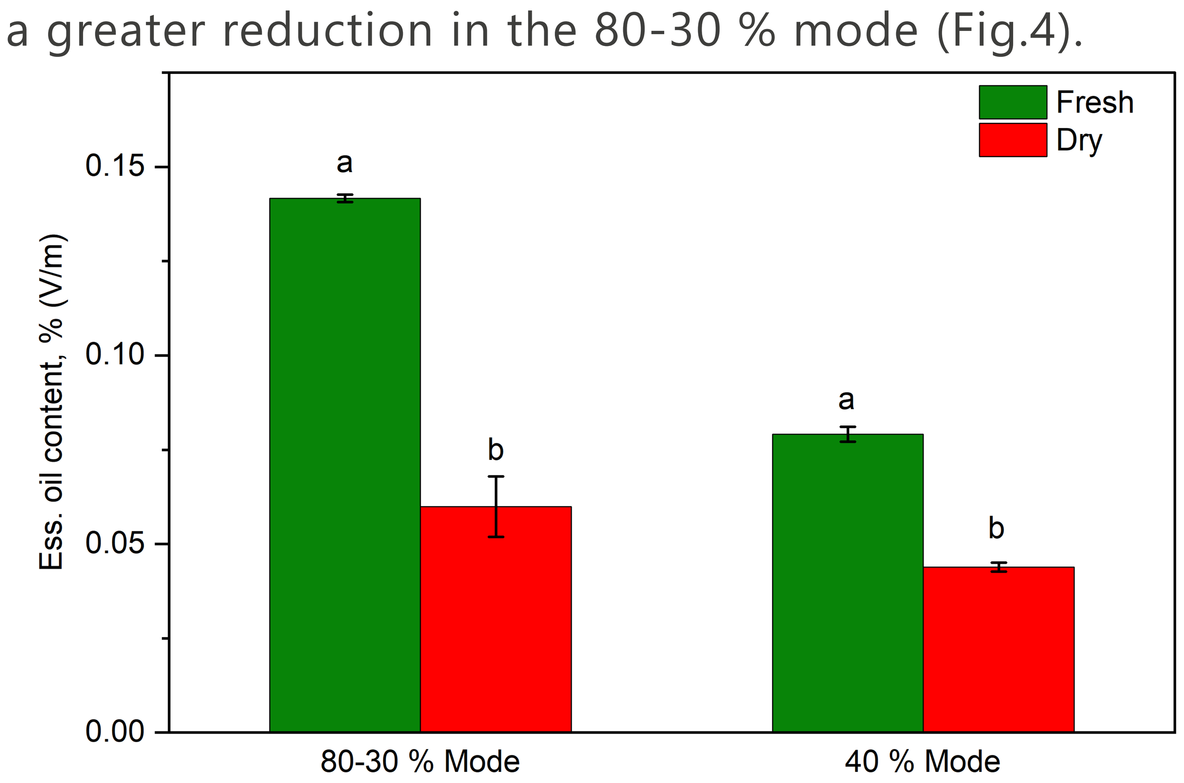

Fig. 4: Oil content of fresh and dried lemon balm for different drying modes.

IV. CONCLUSION

Drying results indicated that operating the dryer in controlled mode with 40% inlet relative humidity was effective, reducing drying time and preventing humidity build-up. The modular dryer offers a practical solution for resource-limited starter MAP farmers. A rolling mode operation, where bottom and top layers are swapped, could help achieve uniform moisture content.

References

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