

Sagar Bhatta, Tatjana Stevanovic Janezic, Cristina Ratti. 2020. Freeze-Drying of Plant-Based Foods. 2020. Jan 13;9(1):87. doi: 10.3390/foods9010087.

3

**Table 1.** Collapse temperature for selected foods during freeze-drying.

Food	Collapse Temperature (°C)
Coffee extract (25%)	-20
Apple juice (22%)	-41.5
Grape juice (23%)	-46
Sweetcorn	-8 to -15
Potato	-12
Tomato	-41
Glucose	-57
Blackberry powder	41
Strawberry	45
Orange juice (14.2% w/v)	51.6
Lactose	-32
Glucose	-40
Gelatin	-8
Dextran	-9
Pineapple Juice (10%)	-41.5
Billberry	-38
Carrot	-37
Radish	-36

Timlehin Martins Oyinloye, Won Byong Yoon. 2020. Effect of Freeze-Drying on Quality and Grinding Process of Food Produce: A Review

4



## Marjojen pakastekuivaus

5

Marjojen haasteita  
pakastekuivauksessa

Sokeripitoisuus

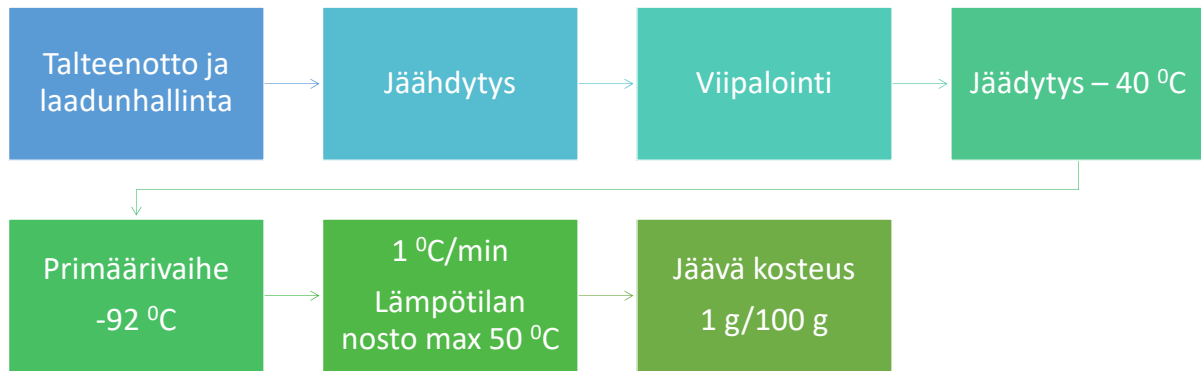
Marjan rakenne

Happamuus



6

# Mansikan pakastekuivausprosessi



7

## Mansikan koon vaikutus pakastekuivatukseen aikaan

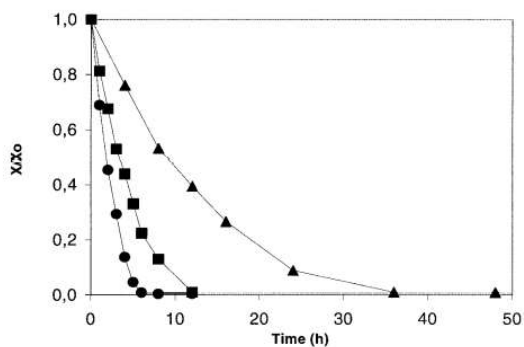
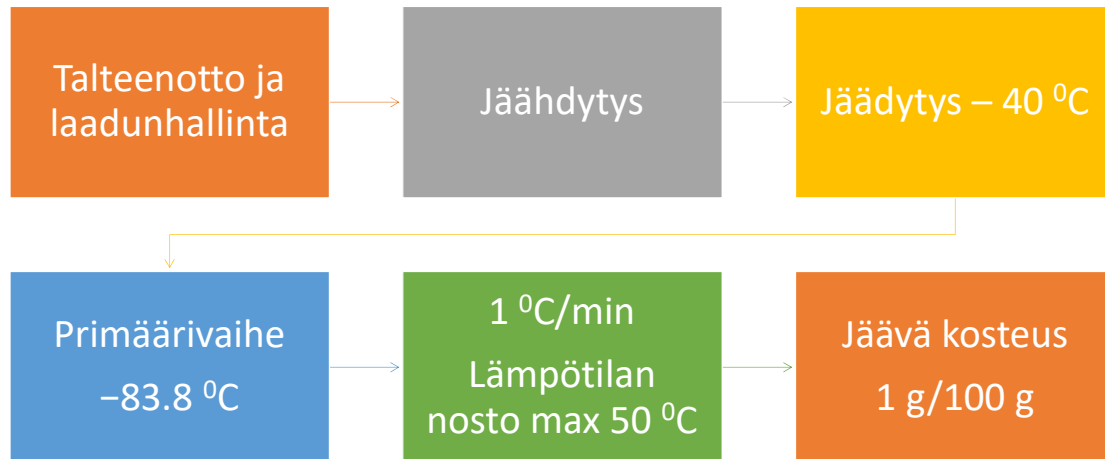


Figure 1. Drying curves of whole (▲), 5 mm (●) and 10 mm (■) slices of berries, freeze-dried at room temperature ( $26 \pm 1^\circ\text{C}$ ) ( $X_0$  = initial moisture content dry basis,  $X$  = moisture content dry basis).



8

## Vadelman pakastekuivaus 48 h



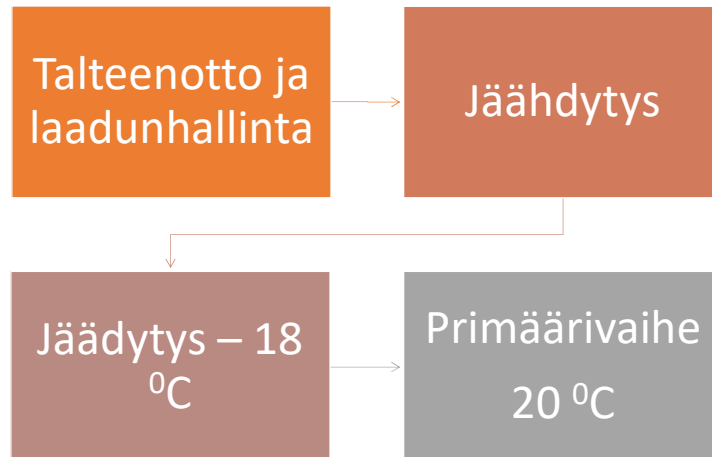
9

## Vadelman kuivaustavan vaikutus aktiiviaineiden määrään

Experimental Factors		Measured Values					
		Ascorbic Acid (mg/100g <sub>d.b.</sub> )	Total Phenolic Content (gGAE/100g <sub>d.b.</sub> )	Total Flavonoid Content (mgCAE/100g <sub>d.b.</sub> )	Anthocyanin Content (mg/100g <sub>d.b.</sub> )	Radical Scavenging IC50 (mg <sub>d.b.</sub> /MI)	
Fresh dried	0.5 m·s <sup>-1</sup>	80	<0.25 <sup>d</sup>	0.921 ± 0.010 <sup>k</sup>	315.1 ± 8.9 <sup>cde</sup>	215.3 ± 8.6 <sup>hi</sup>	0.097 ± 0.0011 <sup>g</sup>
		70	2.45 ± 0.22 <sup>cd</sup>	0.985 ± 0.018 <sup>ij</sup>	298.8 ± 5.4 <sup>de</sup>	287.0 ± 9.4 <sup>c</sup>	0.218 ± 0.0015 <sup>a</sup>
	1.5 m·s <sup>-1</sup>	80	4.04 ± 0.34 <sup>cd</sup>	1.152 ± 0.020 <sup>d</sup>	317.4 ± 6.5 <sup>cde</sup>	256.1 ± 14.6 <sup>ef</sup>	0.198 ± 0.0011 <sup>b</sup>
		70	2.53 ± 0.33 <sup>cd</sup>	1.075 ± 0.003 <sup>ef</sup>	299.3 ± 16.0 <sup>de</sup>	235.5 ± 6.4 <sup>fg</sup>	0.210 ± 0.0065 <sup>b</sup>
		60	7.65 ± 0.27 <sup>cd</sup>	1.281 ± 0.028 <sup>b</sup>	352.7 ± 14.7 <sup>ab</sup>	242.8 ± 12.5 <sup>fg</sup>	0.101 ± 0.0025 <sup>g</sup>
		80	22.54 ± 1.28 <sup>b</sup>	1.202 ± 0.003 <sup>c</sup>	331.8 ± 15.6 <sup>bc</sup>	248.5 ± 5.7 <sup>ef</sup>	0.124 ± 0.0010 <sup>de</sup>
Frozen dried	0.5 m·s <sup>-1</sup>	80	<0.25 <sup>d</sup>	0.994 ± 0.001 <sup>ij</sup>	290.0 ± 15.0 <sup>e</sup>	206.2 ± 16.7 <sup>i</sup>	0.135 ± 0.0055 <sup>d</sup>
		70	<0.25 <sup>d</sup>	1.080 ± 0.002 <sup>ef</sup>	302.1 ± 20.1 <sup>cde</sup>	205.3 ± 5.9 <sup>i</sup>	0.095 ± 0.0010 <sup>g</sup>
	1.5 m·s <sup>-1</sup>	80	8.87 ± 0.90 <sup>c</sup>	1.011 ± 0.006 <sup>hi</sup>	375.5 ± 3.2 <sup>a</sup>	276.0 ± 11.7 <sup>cd</sup>	0.084 ± 0.0012 <sup>h</sup>
		70	<0.25 <sup>d</sup>	0.976 ± 0.019 <sup>i</sup>	322.4 ± 7.0 <sup>bcd</sup>	227.1 ± 12.2 <sup>gh</sup>	0.182 ± 0.0075 <sup>c</sup>
		60	6.58 ± 0.46 <sup>cd</sup>	1.029 ± 0.015 <sup>h</sup>	361.7 ± 3.5 <sup>a</sup>	238.3 ± 16.6 <sup>fg</sup>	0.111 ± 0.0043 <sup>f</sup>
		80	27.46 ± 1.12 <sup>b</sup>	1.067 ± 0.019 <sup>f</sup>	331.1 ± 9.3 <sup>bc</sup>	263.9 ± 3.4 <sup>de</sup>	0.124 ± 0.0077 <sup>ef</sup>
Freeze dried		115.48 ± 2.29 <sup>a</sup>	1.103 ± 0.019 <sup>e</sup>	327.8 ± 1.24 <sup>cde</sup>	410.4 ± 9.4 <sup>b</sup>	0.064 ± 0.0001 <sup>i</sup>	
Fresh raspberry		118.27 ± 2.88 <sup>a</sup>	1.635 ± 0.025 <sup>a</sup>	386.1 ± 21.1 <sup>a</sup>	511.7 ± 5.0 <sup>a</sup>	0.053 ± 0.0005 <sup>i</sup>	

10

## Tyrnin pakastekuivaus



Drying of Seabuckthorn (*Hippophae rhamnoides* L.) Berry:  
Impact of Dehydration Methods on Kinetics and Quality  
Monica Araya-Farias,<sup>1</sup> Joseph Makhlof,<sup>2</sup> and Cristina Ratti

11

Compound retention ( $c/c_0$ ) of seabuckthorn fruits after 15 h of drying

Compound	Air drying		Freeze drying	
	50°C	60°C	20°C	50°C
Moisture content	0.025 ± 0.001	0.006 ± 0.000	0.002 ± 0.002	0.004 ± 0.001
Vitamin C	0.67 ± 0.015	0.61 ± 0.009	0.81 ± 0.011	0.90 ± 0.017
Vitamin E	0.70 ± 0.020	0.65 ± 0.026	0.66 ± 0.028	0.59 ± 0.018
Total carotenoids	0.36 ± 0.012	0.45 ± 0.019	0.78 ± 0.010	0.79 ± 0.021
Total phenolics	0.89 ± 0.080	0.86 ± 0.013	0.96 ± 0.008	0.99 ± 0.023

12

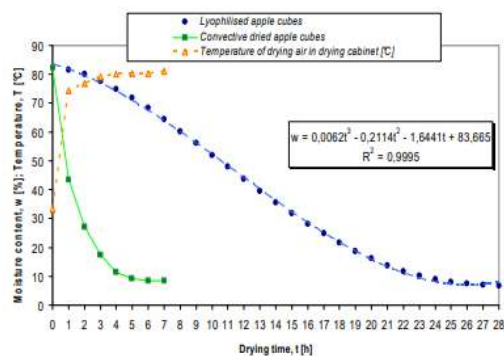


## Haasteita marjojen pakastekuivauksessa

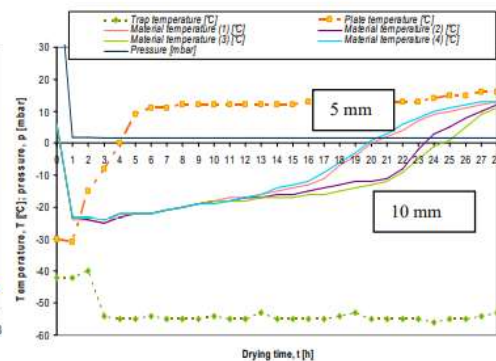
Seabuckthorn berries [44]	Pulp and seeds	T (shelf) = 20 or 50 °C Pressure = 4 Pa Time = 24 h	Drying kinetics; nutritional composition
Seabuckthorn berries/leaves/seeds [56]	Crushed	FD Process conditions = n/a Time = 48 h	Moisture; water and oil absorption; color; structure; antiradical activity
Strawberries [14]	Sliced or whole fruits	T (shelf) = 30–70 °C Pressure = 4 Pa Time = 12, 24, or 48 h	Color; volume; collapse
Strawberries [46]	Half-cut or Sliced	T (shelf) = 55 °C Pressure = 4 Pa Time = 28 h	Rehydration; color; firmness
Blackberries [10]	Juice with carrier agents	T (not reported if shelf or condenser) = -84 °C Pressure = 0.0004 Pa Time = 48 h	Moisture; Thermal property; density; morphology; antiradical activity

13

## Omenan pakastekuivaus



**Figure 5.** Drying curve of convectively and vacuum freeze dried apple cubes for the four varieties inspected

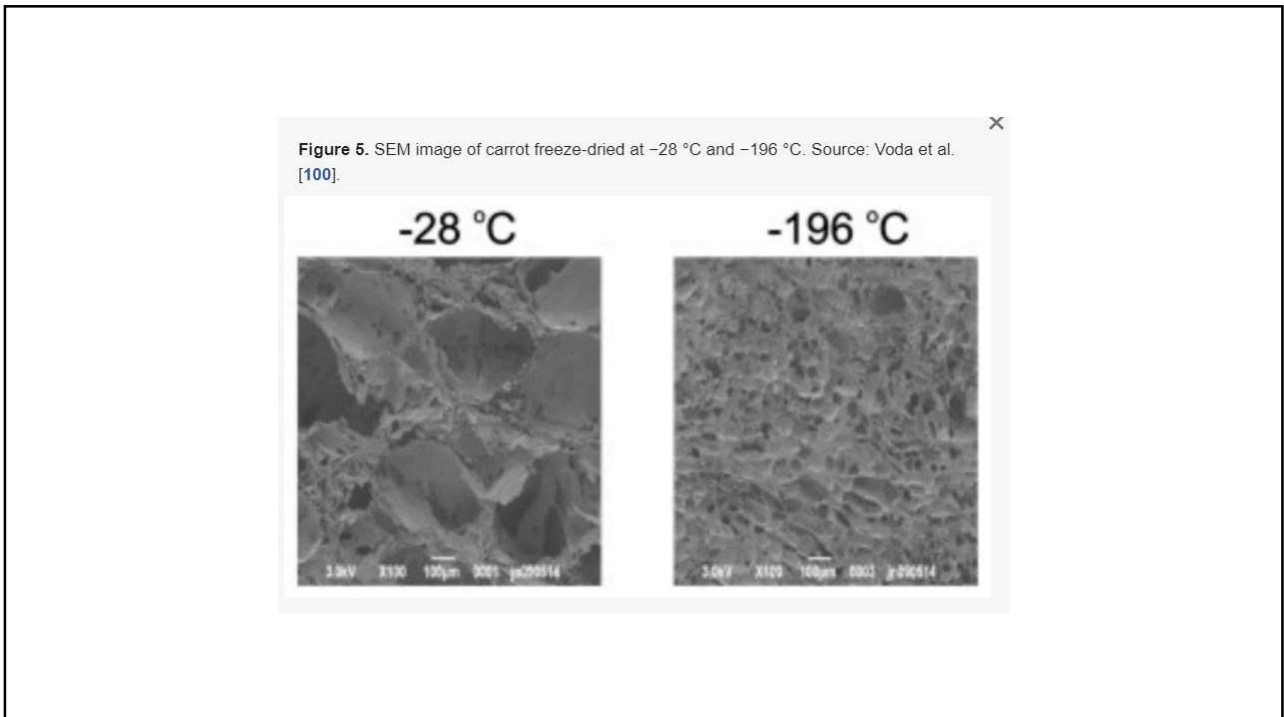


**Figure 6.** Change of temperature and pressure during the freeze drying of apple variety samples of various sizes (5, 10 mm)

14

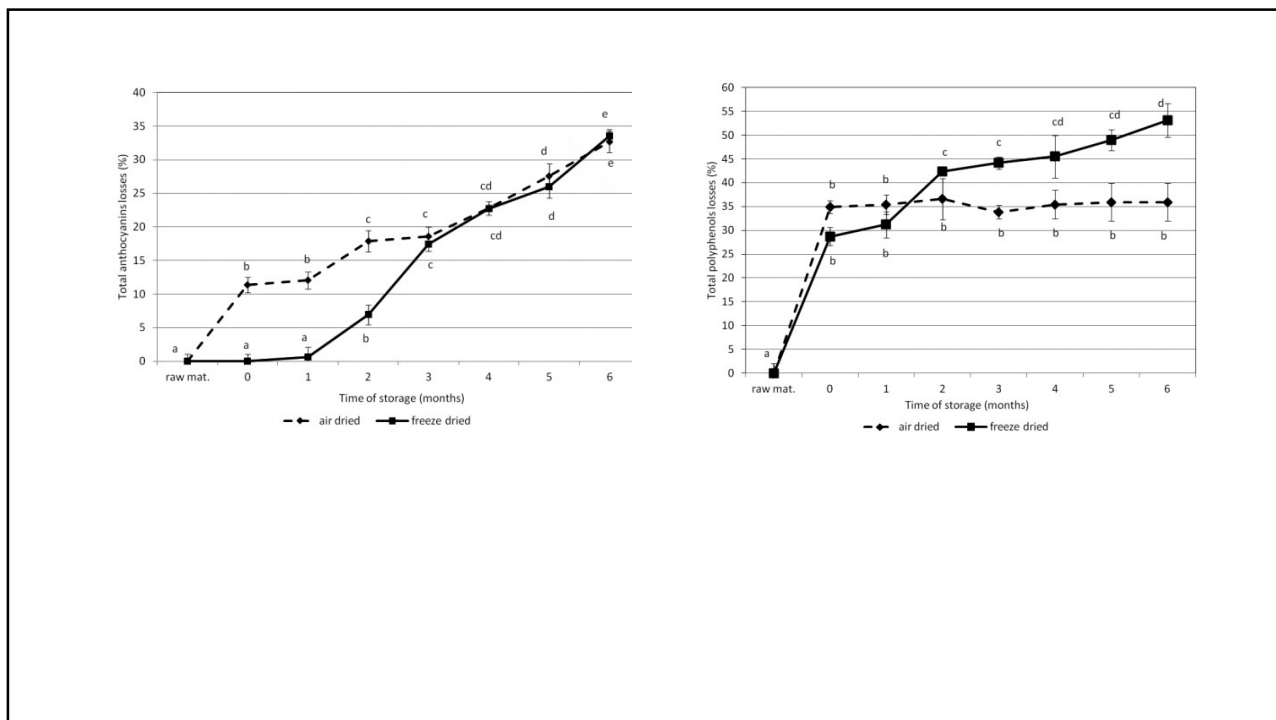


15

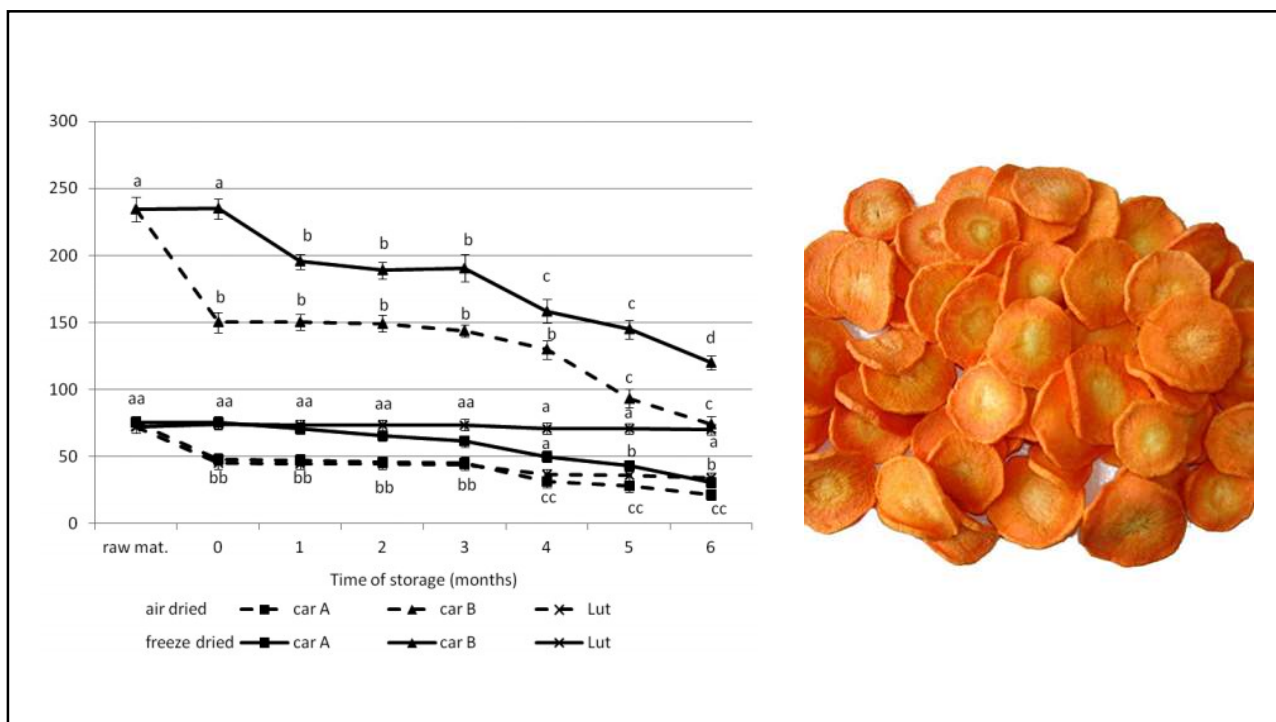


16





17

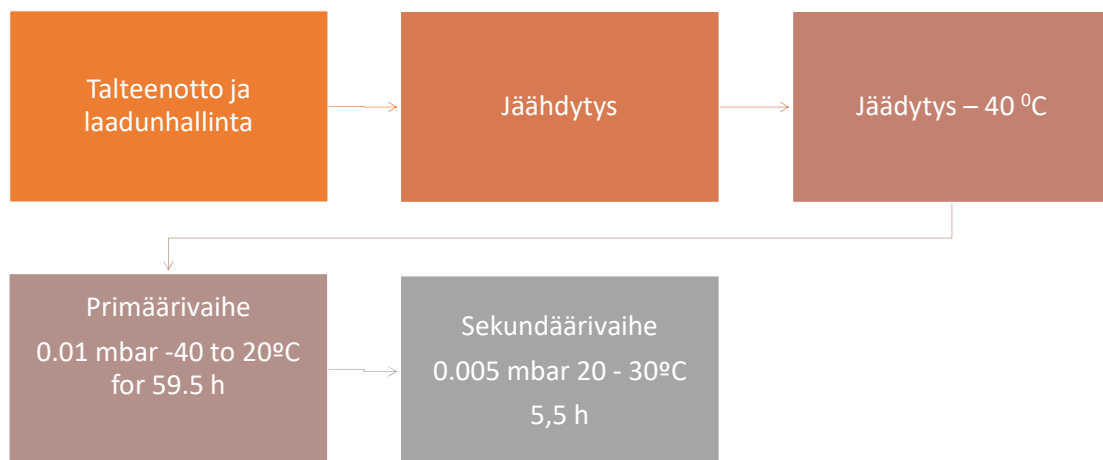


18



19

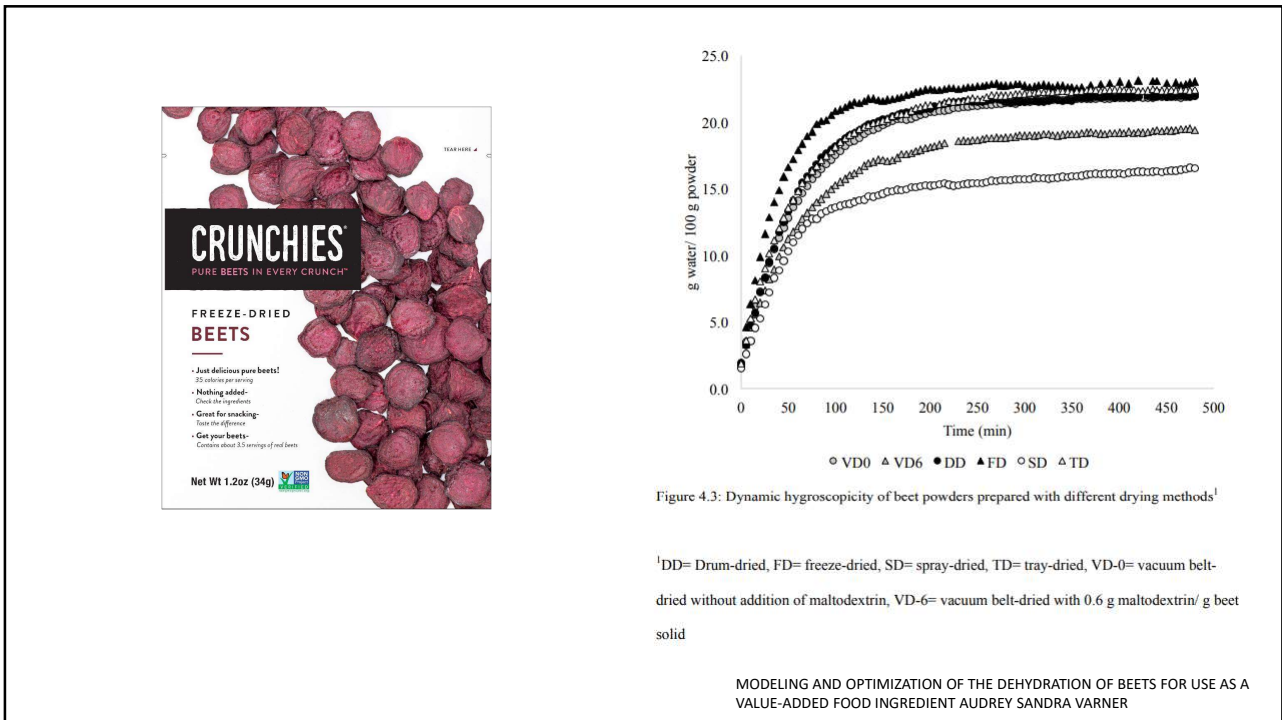
## Punajuurikkaan pakastekuivaus



20



21



22



Pumpkin [49]	2 cm × 2 cm	T (not reported if shelf or condenser) = -47 to -50 °C Pressure = 0.666 Pa Time = 38 h	Texture; color
Pumpkin [6]	10 mm cubes	T (shelf) = 10 °C Pressure = 63 Pa Time = 24 h	Moisture content; water activity; color
Carrot [56]	3-4 mm slices	T (shelf) = 30 °C T (condenser) = -60 °C Pressure = 6 Pa Time = n/a	Moisture content; carotenoid content; lycopene content
Tomatoes/Ginger [11]	Sliced	T (not reported if shelf or condenser) = -50 °C Pressure = 0.001330 Pa Time = 24 h	Total phenolic; ascorbic acid; antioxidant capacity



23



24



## • Yrtit

## • Teekasvit

- Aromi/haihtuvat yhdisteet +
- Karotenoidit -
- Polyfenolit
  - Koivu (lehti) +
  - Paju (lehti) -

Vinita Puranik, D.K. Chauhan, Vandana Mishra and G.K. Rai. 2012. Effect of drying techniques on the physicochemical and bioactive components of selected medicinal herbs

	<i>A. paniculata</i> leaf powder	<i>B. diffusa</i> leaf powder
Sun drying	7.4 mg/100 g	5.67 mg/100 g
Hot air oven drying	15.21 mg/100 g	12.53 mg/100 g
Vacuum drying	29.66 mg/100 g	27.51 mg/100 g
Freeze drying	36.42 mg/100 g	32.44 mg/100 g

Table 5: Effect of drying on total phenol content and % RSA

	<i>A. paniculata</i> leaf powder		<i>B. diffusa</i> leaf powder	
	TPC (%)	%RSA	TPC (%)	%RSA
Sun drying	2.33	24.11	2.12	25.14
Hot air oven drying	7.14	59.14	7.76	61.24
Vacuum drying	13.67	68.66	13.78	70.12
Freeze drying	18.31	74.33	19.62	76.12

Table 6: Effect of drying on mineral content in *B. diffusa* leaf powder

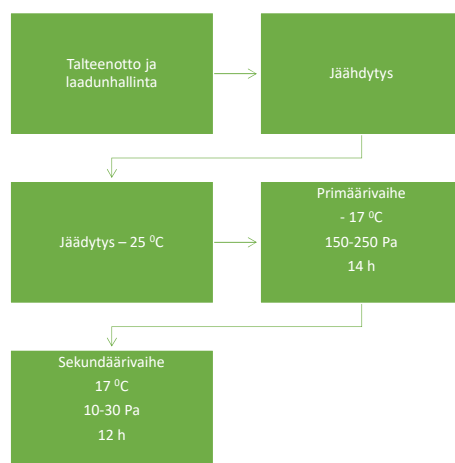
	Fresh	Sun drying	Hot air oven drying	Vacuum drying	Freeze drying
P mg/100g	151.005	150.89	151.76	151.45	151.896
Na mg/100g	160.2	160.04	160.22	160.21	160.26
Ca mg/100g	218.24	218.2	218.14	218.11	218.74
Mg mg/100g	8.93	8.478	8.785	8.56	8.83
Fe mg/100g	0.034	0.035	0.033	0.034	0.039

Table 7: Effect of drying on mineral content in *A. paniculata* leaf powder

	Fresh	Sun drying	Hot air oven drying	Vacuum drying	Freeze drying
P mg/100g	250.13	250.23	250.21	250.45	250.526
Na mg/100g	152.50	152.640	151.87	151.83	152.39
Ca mg/100g	318.62	317.97	317.62	317.67	317.97
Mg mg/100g	9.68	9.67	9.61	9.66	9.67
Zn mg/100g	0.44	0.434	0.433	0.45	0.46
Fe mg/100g	0.012	0.0115	0.012	0.0121	0.0124

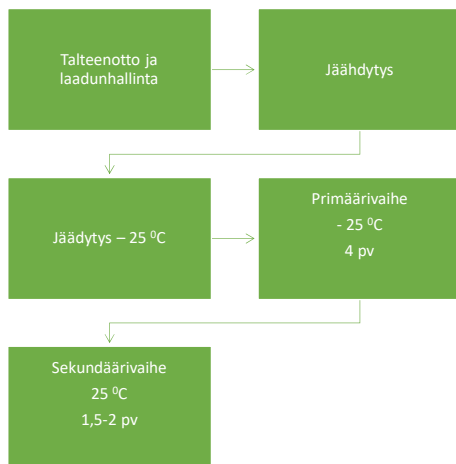
25

## Mintun pakastekuivaus



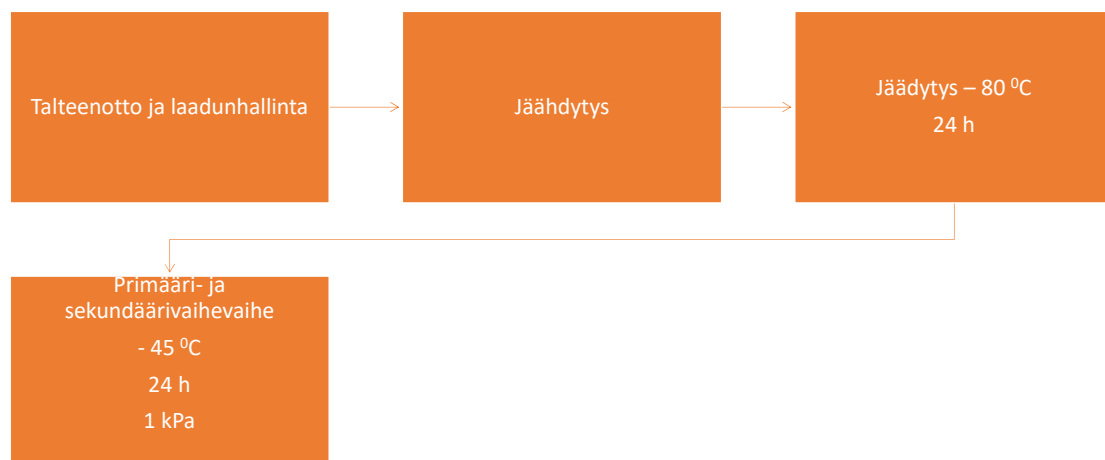
26

## Kuusenkerkän pakastekuivaus



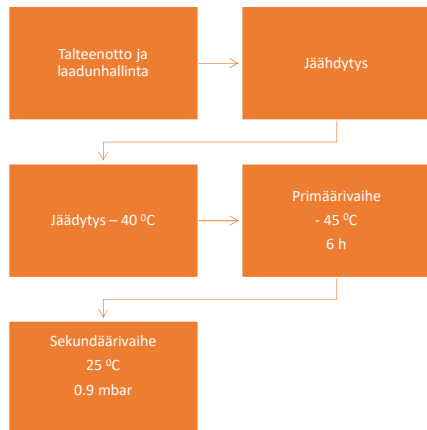
27

## Herkkutatin pakastekuivaus



28

## Herkkusienen pakastekuivaus



29



## Hunajan ja siitepölyn pakastekuivaus

30



Hunaja  
 Hunajajauhe  
 Granuloitu hunaja  
 Hunajahiutalet

Talteenotto ja  
 laadunhallinta

Jäähdytys  
 -40 °C

Primaärivaihe  
 +20 °C  
 7-9 h  
 0.133 mbar

Sekundäärivaihe  
 100 °C  
 50 Pa

31

Table 1. Bee honey sample properties

VD – Vacuum drying, FD – Freeze drying (lyophilization)							
Type of honey	State of sample	Hand held Honey Refractometer		Testo 650 System		IHC Methods, 2009	
		TSS, °Brix	Water, %	Water activity, aW	Temperature, °C	HMF, mg/kg	Diastase activity, DN
<b>Composition criteria for Honey [1]</b>		<b>not less than 80</b>	<b>not more than 20</b>	<b>not more than 0.60</b>	<b>not more than 45</b>	<b>not more than 40</b>	<b>not less than 8</b>
Sunflower honey	Fresh	80.5	17.9	0.558	23.4	38	19.2
	VD	89.5	10.5	0.405	21.1	-	-
	FD	88.9	10.1	0.425	22.3	65	12.1
Acacia honey	Fresh	82.5	17.5	0.598	23.4	16.5	19.2
	VD	88.3	11.7	0.417	22.4	-	-
	FD	88.5	11.5	0.427	22.6	23	15.9

Nebojša NEDIĆ, Milan GOJAK, Ivan ZLATANOVIĆ, Nedžad RUDONJA, Kristina LAZAREVIĆ, Milan DRAŽIĆ, Kosta GLIGOREVIĆ, Miloš PAJIĆ. 2020. STUDY OF VACUUM AND FREEZE DRYING OF BEE HONEY

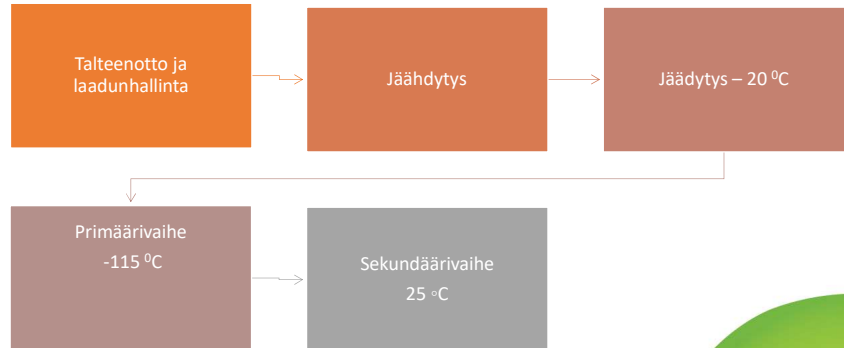
32





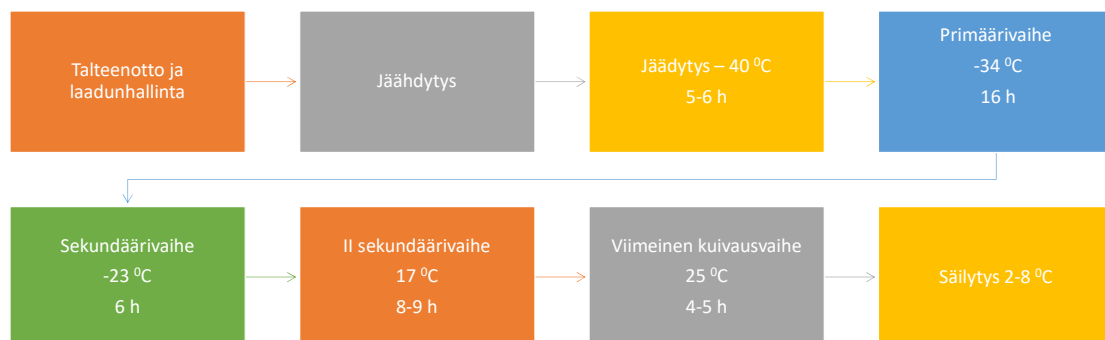
## Siitepöly 9 h

- Sisältää vettä 15-30%
- Kuivumiseen vaikuttaa siitepölyn laji



33

## Propolis



34



Pakastekuivattujen raaka-aineiden  
käyttö elintarvikkeissa ja  
pakastekuivaus elintarvikkeille

35



## Esimerkkejä jatkojalosteista

- Napostelutuotteet
- Välipalat
- Erä/vaellusruuat
- Leivonta
- Maitovalmisteet; jäätelöt, juustot, jogurtit,
- Viljavalmisteet; murot, granolat, puurosekoitukset
- Juomat – juomajauheet
- Kasvisruuat
- Liha-, kala- ja kananmuna

36

Kiitos!

Idea Nature Oy

Heli Pirinen

[Heli.pirinen@ideanature.fi](mailto:Heli.pirinen@ideanature.fi)

Tuotekehitystä ideasta markkinoille!

Elintarvikkeet, kosmetiikka, eläinten  
hoito- ja rehuvalmisteet

